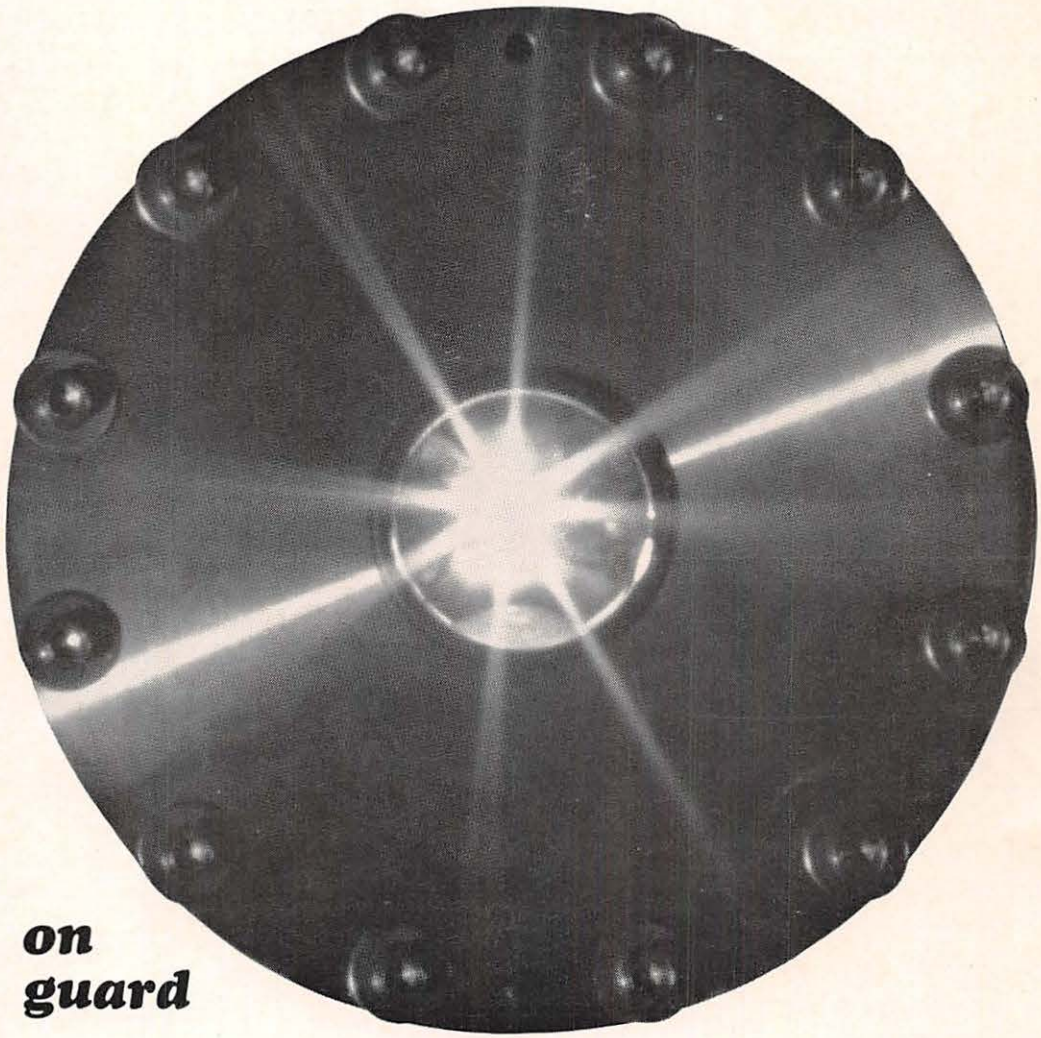
FEBRUARY 1968

Railway Signaling & Communications



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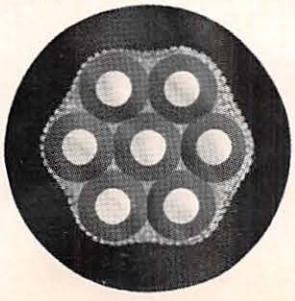

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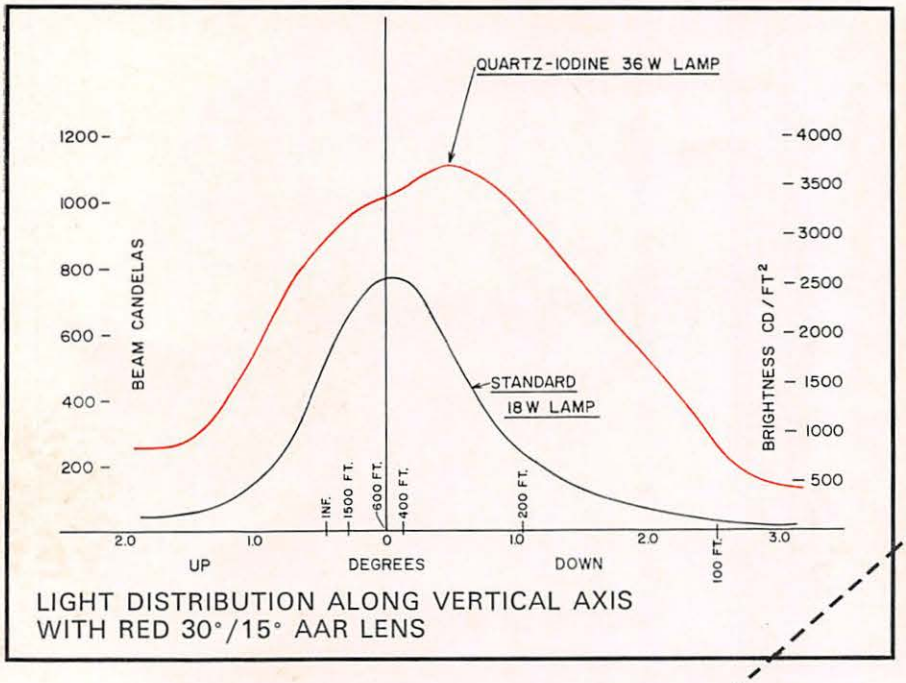

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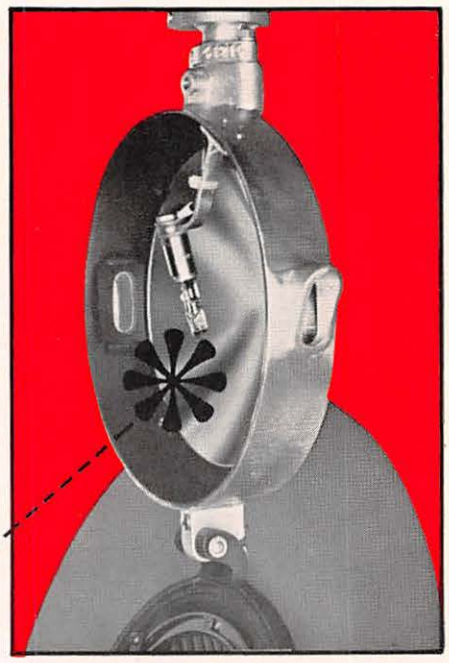

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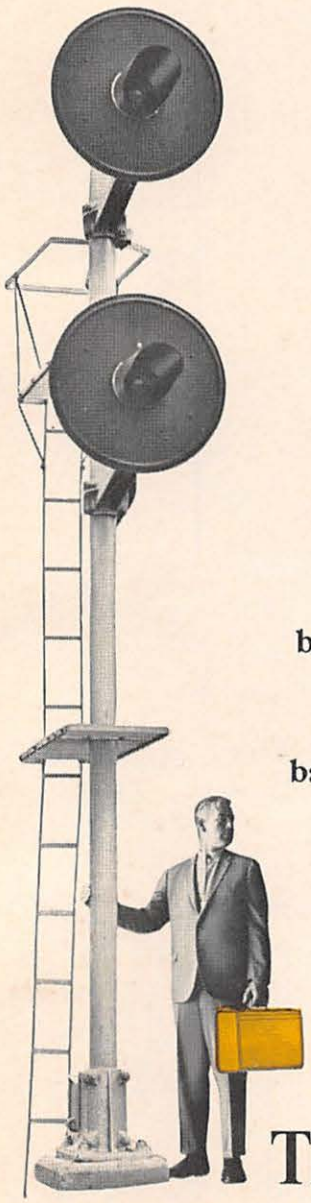

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EDITOR'S CORNER

Two very important meetings are scheduled this spring for signal and communications men, namely the eastern and western sectional meetings of the Communication and Signal Section, AAR. They are important for at least two reasons: (1) being held in Cincinnati and St. Louis, they provide those not able to attend the annual meetings an opportunity to update their knowledge via presentations of technical papers and panel discussions. (2) These meetings provide added incentives for all to freely discuss and exchange ideas, problems and solutions.

In our rapidly changing technology a once-a-year meeting is felt by many to be too long a stretch to go without contact with others. These meetings can and often are an excellent opportunity for a signal and/or communications man to learn a great deal in a short time, namely one day.

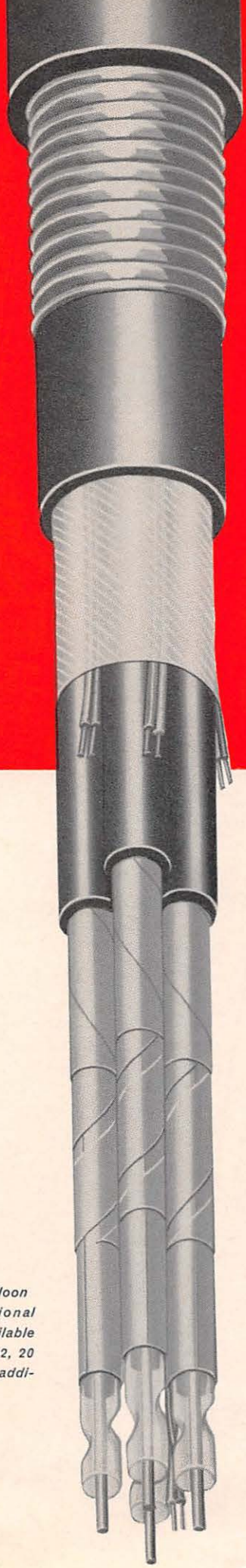
This year there are many topics that might be discussed. For instance, automatic car identification is not far away. Freight cars will have to be labeled by Jan. 1, 1970, and certainly many roads will have ACI scanners in service long before then. With AAR's TRAIN system to be on-stream by late 1969, there are going to be many refinements and final tune-ups to railroad communications systems necessary to meet the in-service dates of TRAIN and ACI.

Some comment has been made that these sectional meetings are becoming too engineering oriented, with not enough down-to-earth solutions to problems at the supervisor's or field level. Discussion of hotbox detector maintenance might be in order. How the supervisor fits in with the training of signal and communications employees should have widespread interest.

Whatever this year's programs, these sectional meetings are a wonderful opportunity that should not be missed. The St. Louis meeting will be held on April 9 at the Gateway Hotel. The Cincinnati meeting will be held on May 2 at the Netherland Hilton.

We hope to see you in St. Louis and Cincinnati.

Elsworth L. Abbott, Serf
Robert W. McKnight, Pariah



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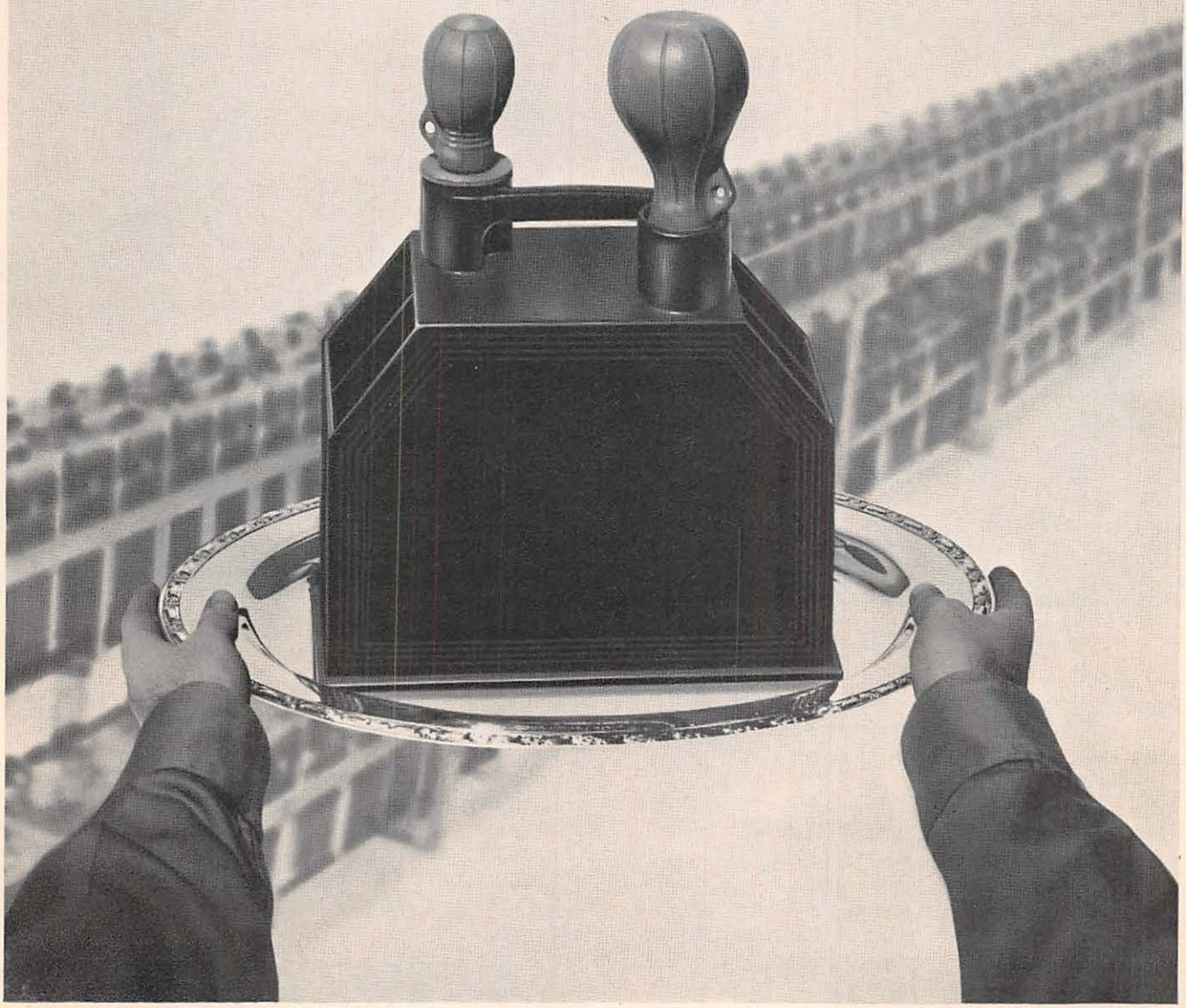

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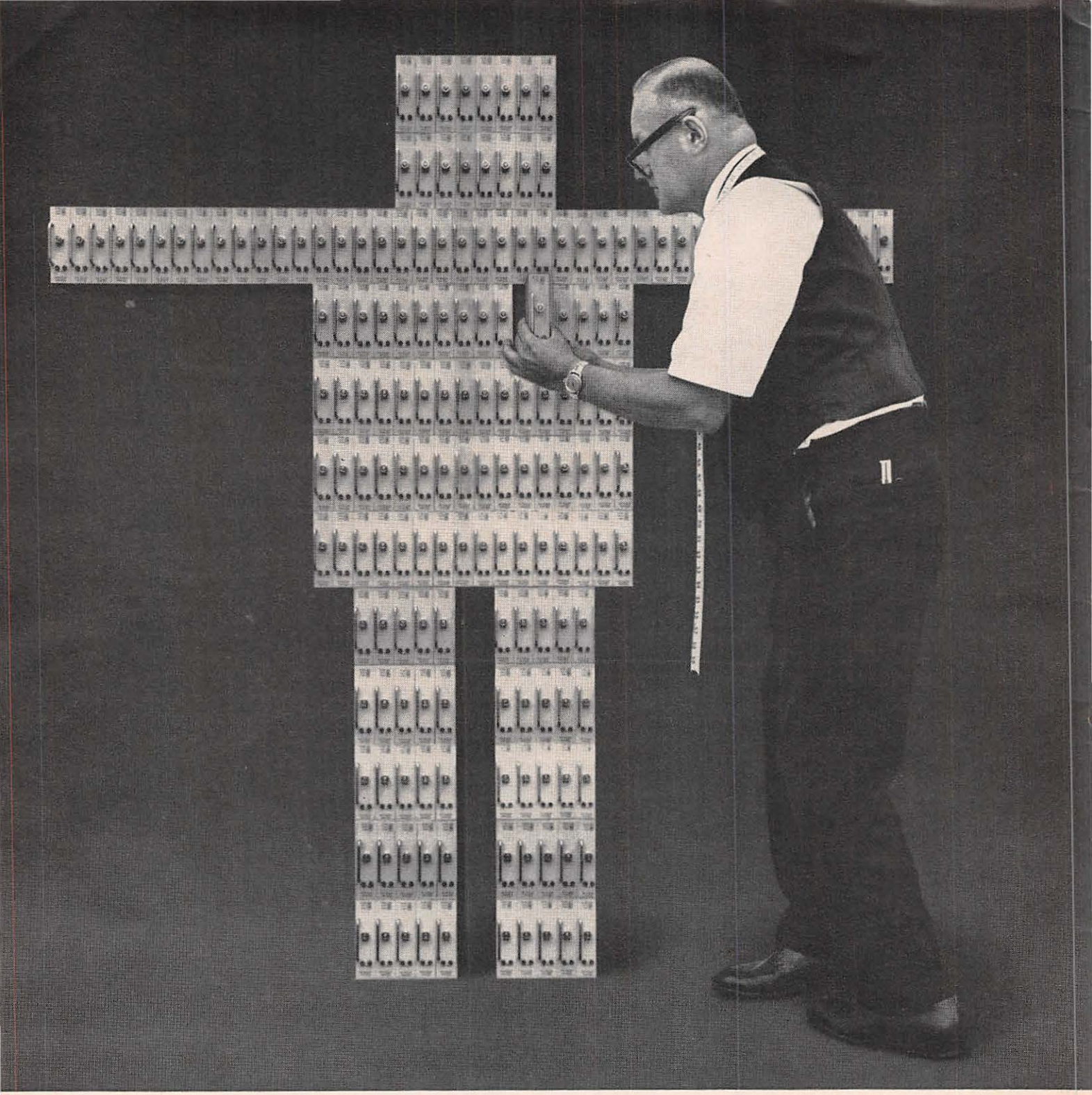

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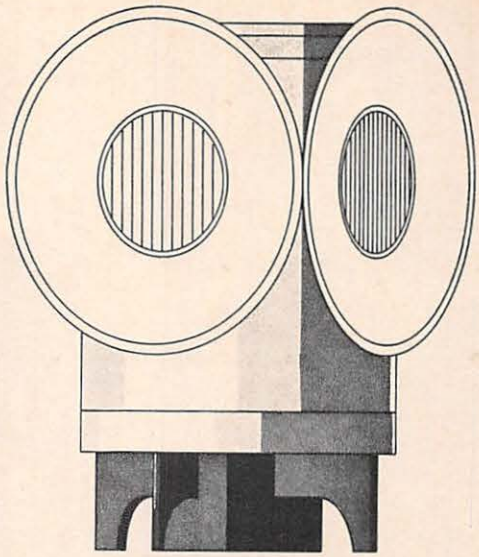

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L&N dispatchers have control of wayside radio stations

By M. R. Williams
Engineer Communications System
Louisville & Nashville

Louisville & Nashville is in the last phase of completing the installation of dispatcher-controlled radio on the entire railroad. At no time will a road engine ever be out of radio contact with the train dispatcher. The possibility, the cost, the worth, and the use of such expansions as radio flagging and dispatcher-controlled radio was discussed many times by many people. It was recognized very early that the first requisite for such systems was that all engines had to be radio equipped. With over 800 engines at over $1,500 per engine, this could only be done on a progressive basis.

Editor's Note: This is an abstract of a paper delivered at the annual meeting of the Communication & Signal Section, AAR, held in Chicago in October 1967.

However, by 1964 the investment made in maintenance-of-way mechanized equipment was so substantial that it had become too expensive to permit it to be idle any longer than might be necessary to pass trains. Therefore, in order to get more production out of this equipment, we were authorized to install radio flagging, which included the installation of radio on all non-equipped engines and making all engines two frequency transmission to facilitate working through the mobile radio repeater stations used for radio flagging, and future expansion to dispatcher control. After all engines were radio equipped, the next logical step was to provide the dispatcher with facilities to contact the trains. In 1964 we were authorized to install dispatcher-controlled radios at the three dispatcher locations between Memphis, Tenn. and Atlanta, Ga.; however, before we had gone very far with this

job we were authorized to make the installation of the dispatcher-controlled radio system on the rest of the railroad, making a total of 14 control points at 11 locations with a radio coverage of 5,580 miles.

In planning for a dispatcher-controlled radio system, various methods of operation are available. The simplest would be to put the dispatcher on the end-to-end frequency with remote-controlled waystations. Our end-to-end radio system was so extensively used that we considered this impractical because of the amount of conversation the dispatcher would have to listen to. A system of signaling could be used to provide the trains a method of signaling the dispatcher, or a private line type of radio could be used to separate the end-to-end conversation from the train to dispatcher conversation. Of course, if economics were not too important, a separate voice circuit could be provided to each waystation, or even a dial system could be used similar to the mobile dial phones that can be installed in automobiles.

On the frequency allotment plan, the L&N had one system-wide, point-to-train frequency, that we had not been able to exploit to its fullest use, so when we laid out the radio flagging job we used this frequency to operate the mobile repeaters with the idea that it would provide facilities for dispatcher-controlled stations with minimum expense.

All road engines are now equipped for two frequency transmission, but only one frequency reception. Thus, it is impossible for the engine crew to miss a call as both the dispatcher-controlled system and the end-to-end system transmits on the same frequency. Channel 1 (161.370 MHz) is the regular end-to-end system and Channel 2 (161.520 MHz) operates through the maintenance-of-way flagging repeater or to the dispatcher through a base station.

We decided to use a standard 30-watt DC radio set for the base stations so that the system could be in operation during a power failure. We found that all available control equipment was AC operated, so we had to have a revision made in the control equipment to meet our requirements. We tried several types of control equipment. The tone operated equipment did not work very well with the voice-keying type of repeaters we use on the dispatchers' circuits. We tried to use a two-out-of-five type of code equipment, but it was unsatisfactory due to being operated by noise.

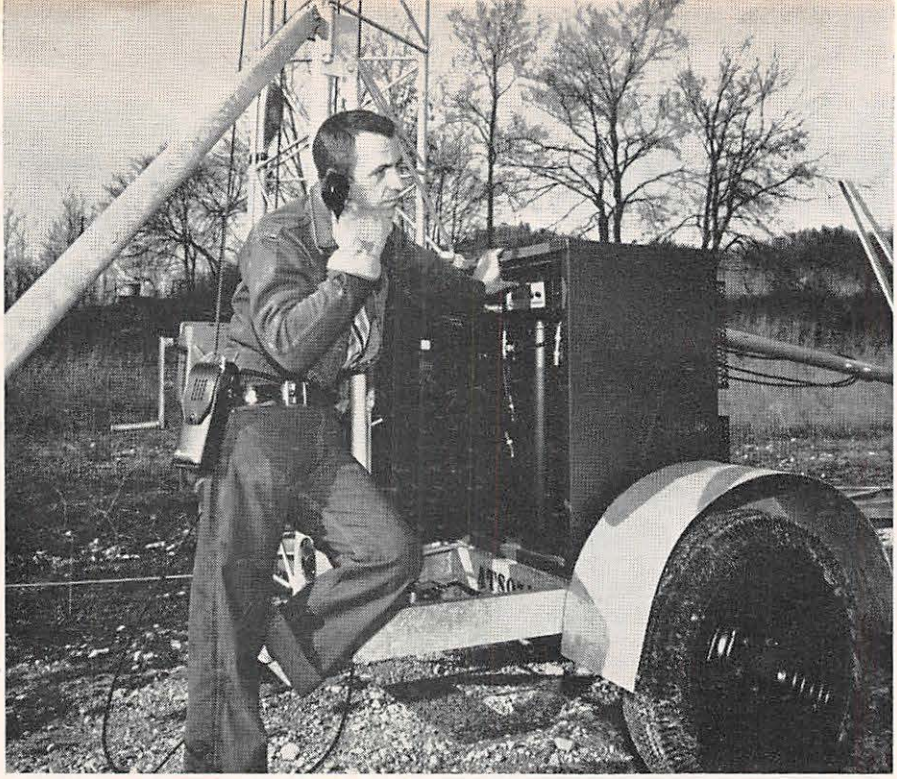
The old reliable 3½ cycle ringing with BP selectors and simplex keying was resorted to again. However, this system leaves a lot to be desired in the number of controls and indications that can be handled. We use a 60 BP selector to ring on or off the radio station. Normally the receivers are across the dispatchers' telephone circuit and are being monitored by the dispatcher. We use a high-resistant simplex circuit to key the transmitter, which permits us to retain the few phantom circuits we have in use. Reverse battery on the simplex circuit mutes all receivers so that at any time a radio receiver interferes with a dispatcher's work he can immediately mute it.

We have 14 dispatchers' positions at 11 locations so we knew where and how many control points we needed. However, the location of the controlled base stations were not so easy to determine. We studied the topographic maps and laid out a likely location to provide the necessary radio coverage with about a two-mile overlap. From past experience, we knew that we could get about a 25-mile radius of coverage with a 30-watt radio and a 70-ft high antenna. Atfer the locations were tentatively spotted, we had a survey team cover the system to check the performance of a station located at the tentative site and then picked a site exactly to give the best coverage. This survey team consisted of two men with a pick-up truck and one of our maintenance-of-way radio relay trailers, and a radio-equipped high-rail pick-up truck. The maintenance-of-way flagging trailer is a two-wheeled, utility-type trailer with a 60-ft telescoping tower, a radio relay station, that can be operated as a local controlled base station and the operating storage batteries. The trailer was set up and the high-rail truck made a run over the territory talking to the base station and measuring the limiter voltage. Alternate sites were usually checked and the best usable site was selected. All stations had to be located adjacent to our pole line because the out-put had to be connected to the dispatchers' telephone circuit. The only exception to this was on two branch lines where Morse operation was in use and we had to use radio relay stations to bring the signal back to the pole line. There is no doubt that the physical survey was well worth the cost as we have not had to move a single station after they were in operation. We have 116 base stations and 4 radio relay stations which provide an average coverage of 48.3 miles. For several reasons we did not use high power radios or very high antennas. Concurrent with the survey we were doing the engineering and design of the other components. We decided to use a 4 ft x 6 ft. fiberglass housing mounted between the antenna pole and a stub pole set for the purpose. We set the antenna pole in our pole line route when possible.

We set the first few locations with one of our line gangs and a line truck. However, we found that this method was going to interfere with the line gang's schedule of work and since this work was going to be of short duration, we contracted the setting of the poles and housing. The contract was let for the entire system and since the survey crew was well out in front, the contractor's rig followed the survey crew on a circle of the entire railroad and averaged about three locations per day. The installation of the equipment was done by two two-man installation crews. There was installed in each housing a radio set, control equipment and a 6-cell 80 a.h. battery and an automatic rectifier. Incidentally, the most versatile and useful tool the installers had was a small portable 100-volt AC generator. This permitted them to use standard power tools, including one to drill the poles. It also permitted charging the batteries and giving the station an operating test before the power company installed their service.

We have three radio stations that due to local conditions had to be controlled by carrier and this gave no problem as the E&M leads are used to key the radio transmitter. There are several radio stations that were located at the control points and have only local control.

The biggest problem we had was to provide radio coverage on two branch lines on which there was no voice circuits and Morse telegraphy was used to dispatch trains. One of these lines paralleled the main line within range of a radio repeater



Mobile repeater used for radio flagging by M/W gangs.

which simplified the problem. We obtained two additional radio frequencies and used three radio relay stations controlled from the main line to provide the necessary coverage. Two of the relay stations were on the same frequency and tone control equipment was used to select the desired repeater.

The other branch line was short enough to get coverage with one radio relay station which was controlled from one of the base stations controlling the first branch line repeater. This permitted radio coverage on nearly 300 miles of branch line with three base stations and four radio relay stations. Incidentally, this would not have been possible a few years ago because it took the very latest front end equipment and techniques, along with directional antennas and corner reflectors to make the radio relay system work.

The dispatcher has complete control of all waystation radios by the use of a small radio console added to the dispatcher's position whether CTC or train order. The existing 62-A selector key was used to ring on or off the waystation radio. The "A", "B", "C", and "D" functions of the 60 BP selectors are used for control functions. "A" rings the bell to call a maintainer while working in the house. "B" places the radio set in monitor position. "C" places the radio set in operating position. "D" removes the radio set from the line. The usual selector ring back was changed to provide a little more information. A short burst of 300, 600, or 900 cycle tones are used to answer the "D", "C", or "B" functions respectively; however, if the DC power is off, a conventional ring back is provided, and if AC power is off, a varying frequency tone is used for the answer back.

At the beginning of each trick, the on-coming dispatcher selects each waystation by sending function "B" on each selector number. This insures that all stations are on the line in a monitored position and that power is on. Normally, all stations are left in this position.

There are two locking-type keys on the radio consoles; one, the main-line radio key which, when in the operate position, connects the simplex battery used to key the transmitter through the footswitch, and light a steady burning green light. A red light will also light when the footswitch is depressed to indicate that a transmitter is keyed. The other key is a mute control key which, when operated, will apply reverse battery to the simplex which will mute all radio receivers except one that has been selected to the operate position by using the "C" function. The mute key permits the dispatcher to have complete control of the radio system because it permits him to remove all radio sets from the line except the one he is talking on.

A six-minute timer will remove the transmitter of a selected station from the air and return the station to the monitor position. However, the six-minute timer will restart each time the transmitter is keyed so that in normal use, the transmitter will not time off. Another timer set for three minutes will remove a transmitter that is continuously keyed from the air.

The train dispatcher may be called from any road engine or equipped automobile by moving the selector switch to channel 2 and transmitting. Proper identification and location is required so that the dispatcher can determine which station he has to key on line in order to establish radio contact with the calling party. He does this by sending the "C" function of the desired station number on his 62-A selector key, and operating the main line radio key to the operate position. The dispatcher can call any train or equipped automobile that is within range of a station, by selecting a base station and transmitting. In case of a train it is not too difficult for the dispatcher to select the proper station; however, it may be necessary to select more than one station to locate the proper vehicle. This is no problem because the dispatcher will transmit simultaneously on all selected stations, and he can select as many as he chooses.

The facilities this system provides the dispatcher is such that he is very much concerned when there is an outage. It permits him not only to know exactly where a train is, but also how it is performing so that he can make better decisions as to where trains are to meet or which train to move first. It would be impossible to calculate the amount of time saved on the improved performance of trains that has resulted by providing radio communication between the dispatcher and the trains. There have been a number of potential wrecks and derailments prevented by being able to contact the engineer promptly about shifting loads, hotboxes, etc.

During the testing out of the system on one division, the installation crew left a couple of the base stations on the line as they were working satisfactorily. During the night the chief dispatcher called the radio inspector at the motel and told him to come out and get the rest of the stations in because they needed them. **RS&C**

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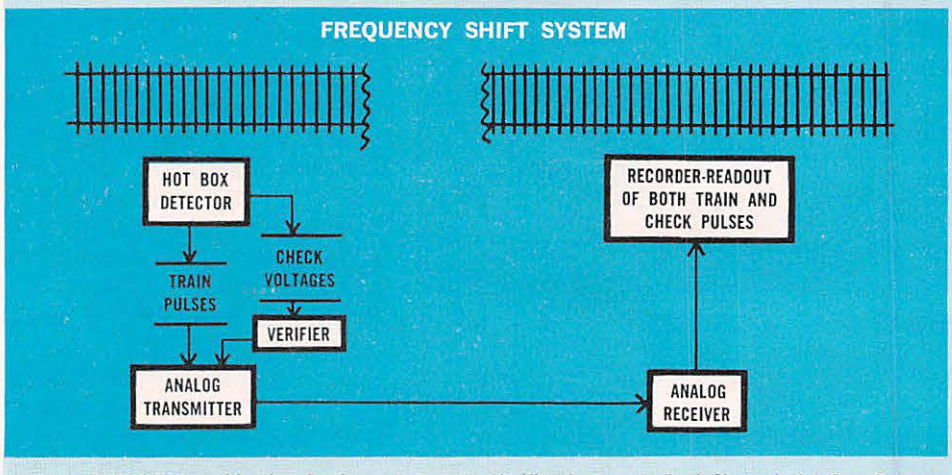

HARMON'S combination Carrier and Detector-Verifier System, a Dual Channel Hot Box Detector Analog FM Carrier Model 510C and the Hot Box Detection System Verifier Model 901A.

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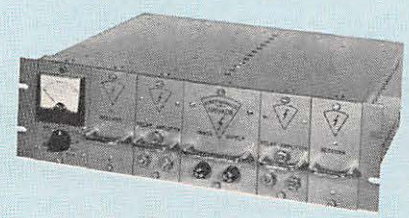

DUAL CHANNEL DIGITAL CARRIER FSK

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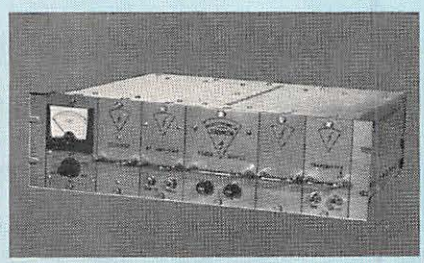

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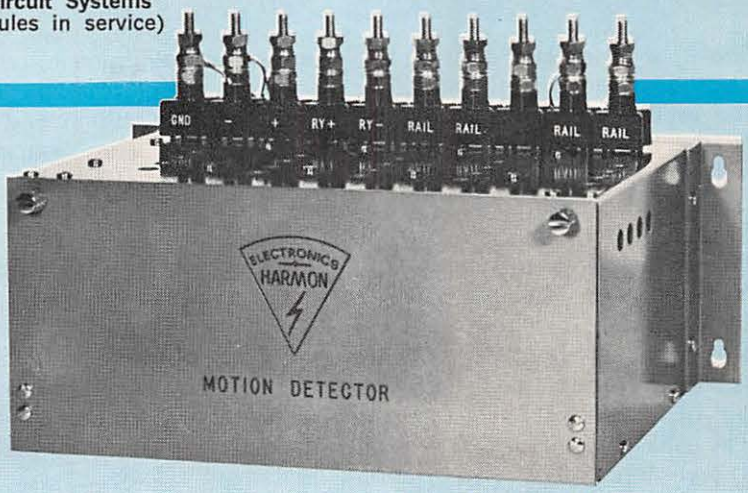

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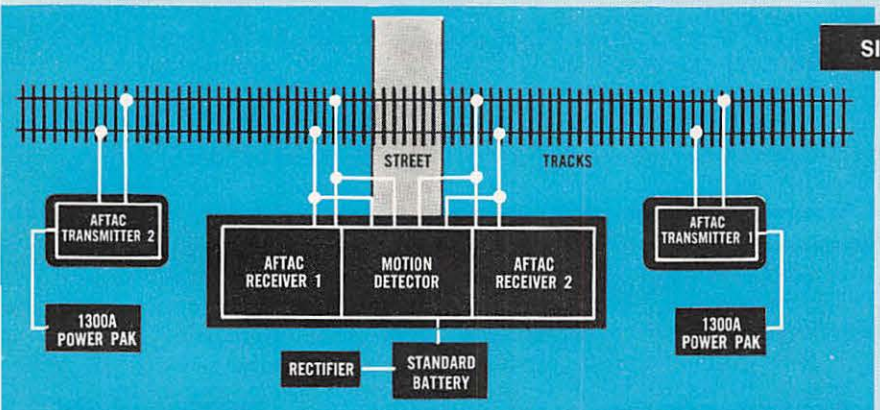

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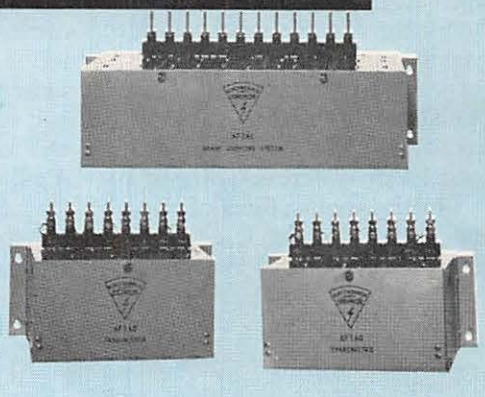

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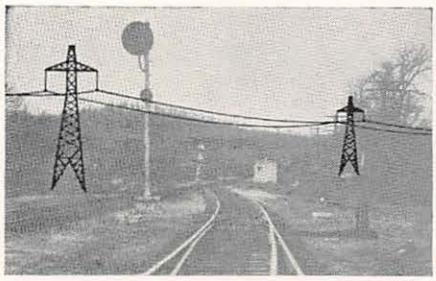


Economics of HVDC are recognized

The benefits of long-distance DC transmission are now beginning to be realized in the United States with the latest projects under construction or under consideration such as the Pacific Intertie.

While DC terminals are complex and relatively expensive, the DC transmission line is considerably less costly than its AC counterpart. The ratio of costs is about 2-to-3 in the case of overhead lines, and only about 1-to-3 or less for cables.

The ASEA Company in Sweden has been foremost in the development of HVDC conversion equipment as evidenced by five projects completed and in operation with a sixth scheduled for completion, all of which incorporated terminal equipment of ASEA design and manufacture. The key item is their success in developing a high-capacity, high-voltage valve.

The measure of economic worth of a given transmission facility is usually expressed in terms of investment or annual cost related to the power delivered in kilowatts or megawatts at a particular distance. The cost included in the comparisons of Figure 1 include those of the lines plus all necessary terminal and intermediate substation equipment required to transmit power from the high voltage bus at the sending end to the receiving bus. The comparison between 230 and 500 kv AC illustrates the desirability of going to EHV levels for transmission of larger blocks of power. Since DC requires only two conductors and AC three, the AC line costs at least 50% more than a DC line of comparable capacity.

The nature of DC transmission obviates the need for the line compensation so necessary to successful operation of a long-distance EHV AC transmission line. A DC terminal, however, is much more costly than an AC terminal of comparable capacity, since it will contain expensive conversion equipment and, in addition, essentially all the AC facilities that the AC terminal requires. This means that DC is less expensive than AC transmission only when the increment of higher cost of the DC terminal is exceeded by the savings in line and compensation costs.

It is generally uneconomical to tap DC lines. Where taps are required, AC has the economic advantage. For long-distance point-to-point transmission, DC is less costly.

Because underground (or underwater) cable costs range from 5 to 25 times as much as overhead lines of comparable capacity, the economic crossover distance between AC and DC is much shorter for cable circuits. Various authorities estimate from under 30 to over 60 miles depending upon the particular application.

While the valves to be used in the first Pacific Intertie DC line terminal are rated 133 kv at 300 amp per anode, prototypes have been tested at voltages up to 250 kv. It is believed that further development will result in still higher operating voltages and greater current capabilities with attendant reductions in overall costs per kw of power handling capability. For example, specifications call for valves of 200 kv and 900 amp per anode ratings to be used in the second Pacific Intertie DC line.

The design of mercury arc (or ionic) valves does not lend itself to theoretical analysis but depends instead upon emperical data determined by experiments. The valve to be used in the first Pacific Intertie DC line consists basically of a common cathode tank and 6 anodes connected in parallel, with a number of other components that control its function as a high-voltage valve. In the cathode tank are an igniter electrode (I) and an excitation electrode (E) which act to keep a source of ions available at all times so as to facilitate immediate ignition of the arc path and to help prevent "ion starvation," which could result in quenching of the arc. In addition, these serve to maintain proper heating in the cathode tank during standby operation so that the valve will be ready to function instantaneously upon ignition. The grid electrode (G) provides ignition control.

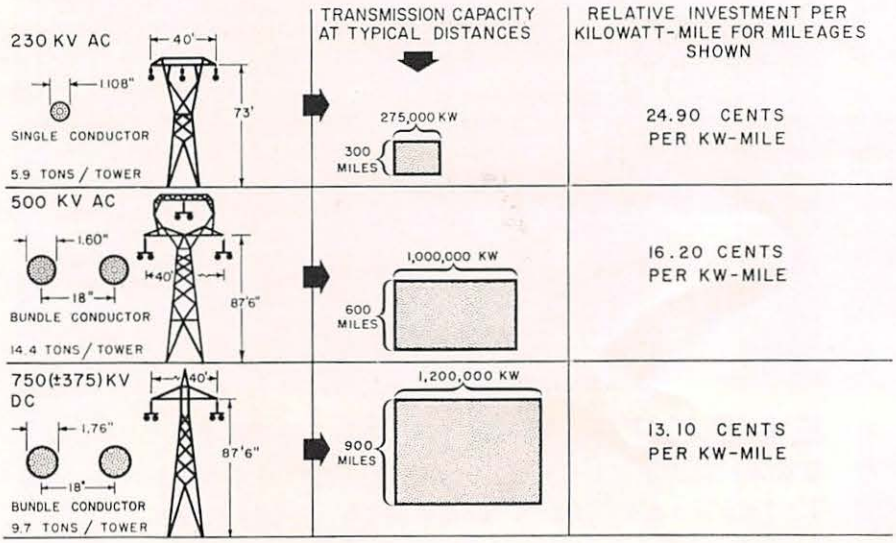
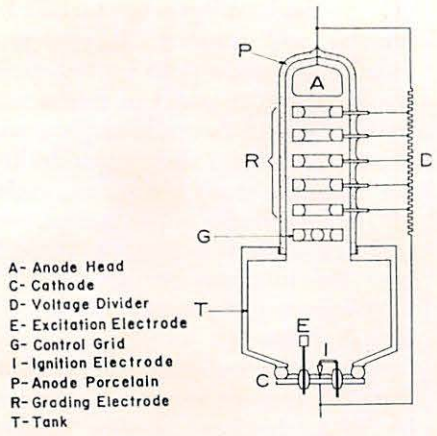


Figure 1. Comparison of transmission capabilities and unit costs of AC and DC single circuit.

Note: Abstract of Paper by R. John Mather and Edward F. Weitzel presented at a Symposium on Effects of HVDC Transmission on Railway Operation, held in Denver, Colorado. Mr. Mather and Mr. Weitzel are with the Bonneville Power Administration.



Ionic Valve

The grid can be biased negatively to the degree that the valve will remain cut off irrespective of the anode voltage. Once ignition takes place, however, as in other grid-controlled mercury rectifiers, the grid loses control and cannot affect current flow through the valve until the anode voltage decreases to the extinction value and the valve through-current ceases.

The grading electrodes (R) with their external resistance-capacitance voltage divider (D) have made possible the high levels of operating voltage of which present day valves are capable. Without these, a nonuniform voltage gradient would exist along the arc path, being extremely high in the vicinity of the anode. This would cause heavy concentrations and high velocities of ions in this region and, in turn, result in "arc-backs" or conduction in the reverse voltage" period. The anode would then act as a cathode.

The grading electrodes provide a uniform voltage distribution along the arc path, virtually eliminating the above problem. Actually, it is presently not possible to eliminate the arc-back of ionic valves entirely, but the effect can be minimized by the control circuit and bypass valve. The frequency of arc-back in the Intertie valves is guaranteed to be no more than 1 per month per 6 valve bridge (7 including the bypass valve).

In addition to the "arc-back" referred to above, other misoperations can occur. These are:

- Quenching, in which the arc path suddenly extinguishes.
- Misfire, in which the arc fails to establish, with a positive pulse applied to the grid, and a positive potential on the anode.
- Arc-through, in which the arc is established with the anode positive but with a negative potential on the grid.

These problems are minimized and controlled through careful design, but as with arc-back cannot be eliminated entirely.

The full-wave bridge connection has proven to be the most efficient for EHV DC transmission. In this bridge connection, at any time, two valves will be conducting in series with their associated transformer secondaries. Each valve will conduct for a period of ⅓ cycle and be nonconducting for ⅔ cycle. A valve reaching the end of its conduction period, together with a third valve which has just begun to conduct, will short circuit the transformer winding, or windings, associated with these valves until the action of the incoming valve causes the first valve to be cut off. This interval, denoted (gamma), known as the commutation or "overlap" period, is of the order of 15 to 20 electrical degrees in duration. Harmonic filters are employed to smooth out the resulting waveform to prevent the harmonics generated by valve action from entering the AC system.

The valves are fired by suddenly applying square wave positive voltages to the control grids. The duration of each of these trigger voltages is ⅓ of a cycle. By shifting the timing of the trigger pulses with respect to the applied system AC voltages, the magnitude and polarity of the DC output voltage can be varied. This phase shift is called the alpha angle. When the DC output voltage is positive with respect to the DC current, the converter is acting as a rectifier and is taking power from the AC system. When the DC output voltage is negative

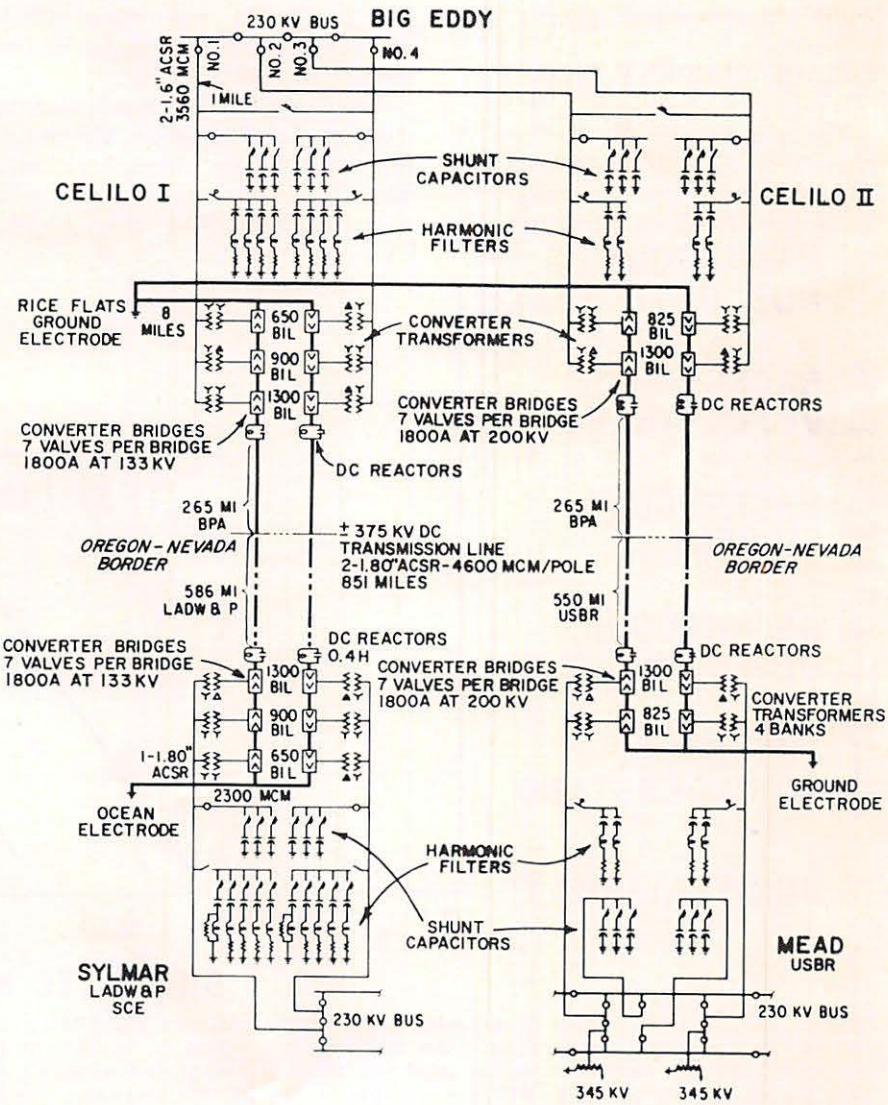


Figure 2. PNW-PSW intertie DC facilities.

with respect to the DC current, the converter is acting as an inverter, and is supplying power to the AC system. Since the current flow through the valves is always in the same direction, the function of the DC system as a rectifier or inverter is determined by the alpha angle control. The magnitude of current flow is determined by the difference in DC voltage between terminals.

The transient fault current (for a DC line fault), can be somewhat greater, but is usually less, than twice normal load current, depending upon the distance of the fault from the nearest terminal. The low magnitudes of DC line faults, (in relation to AC faults), together with their short clearing times, allow rapid deionization of the fault arc path and re-establishment of the insulation level .This in turn allows quick re-energization of the system. Tests indicate that the times for re-energization will be considerably less than those of AC systems of comparable transmission capacity.

DIRECT CURRENT DESIGN

The plan selected for the two DC circuits of the Intertie is shown in Figure 2. Both lines are rated ±375 kv nominal, ±400 kv maximum. The first line from Celilo I to Sylmar will incorporate three bridges on each side of ground, rated 133 kv per bridge and 1800 amp. The valves have 6 anodes and will weigh in the neighborhood of six to seven tons. Six of these valves plus a seventh that serves in a bypass function comprise one bridge. Three bridges in series will form each positive and negative pole of the converter installation. The total complex thus consists of six bridges in series (42 valves) with a midpoint at ground potential and the two ends with 750-800 kv difference in potential. Celilo I and Sylmar Terminals will each have such an arrangement.

Celilo II and Mead Terminals will incorporate a later type valve rated for 200 kv per bridge and 1800 amp. In addition, each valve will have only two anodes. With the higher rating it will be necessary to have only two bridges for each polarity with the total output voltage the same as for the Sylmar Line. With four bridges in series, there will be 28 valves at each terminal in contrast to 42 on the first line.

A high voltage DC test center was completed at The Dalles, Oregon, by Bonneville Power Administration in 1963. The power supply was rated at only 1½ amp but was capable of very high voltage up to 550 kv positive and negative. It was provided that single pole testing, positive or negative, could be performed up to 825 kv. A five mile test line was constructed and a short separate line for long-time study of various insulator designs. Radio noise, corona, wet and dry flashover, leakage currents over the insulator strings, and TV interference investigations have continued at this site.

A separate series of tests distinct from the test center were performed by BPA, the Los Angeles Department of Water and Power and the United States Bureau of Reclamation to investigate the effects of DC ground current from possible electrode sites in Oregon, California, and Nevada.

A peculiarity of the nuisance factor of radio interference, which was entirely unexpected, was the discovery that higher levels of radio noise from DC lines could be tolerated than was the case for AC lines. This may be due to the fact that corona formation occurs at the peak of the voltage wave and the interference, therefore, has a component in the audible range with alternating current which is not present with direct current. Regardless of the theoretical explanation, the actual empirical re-

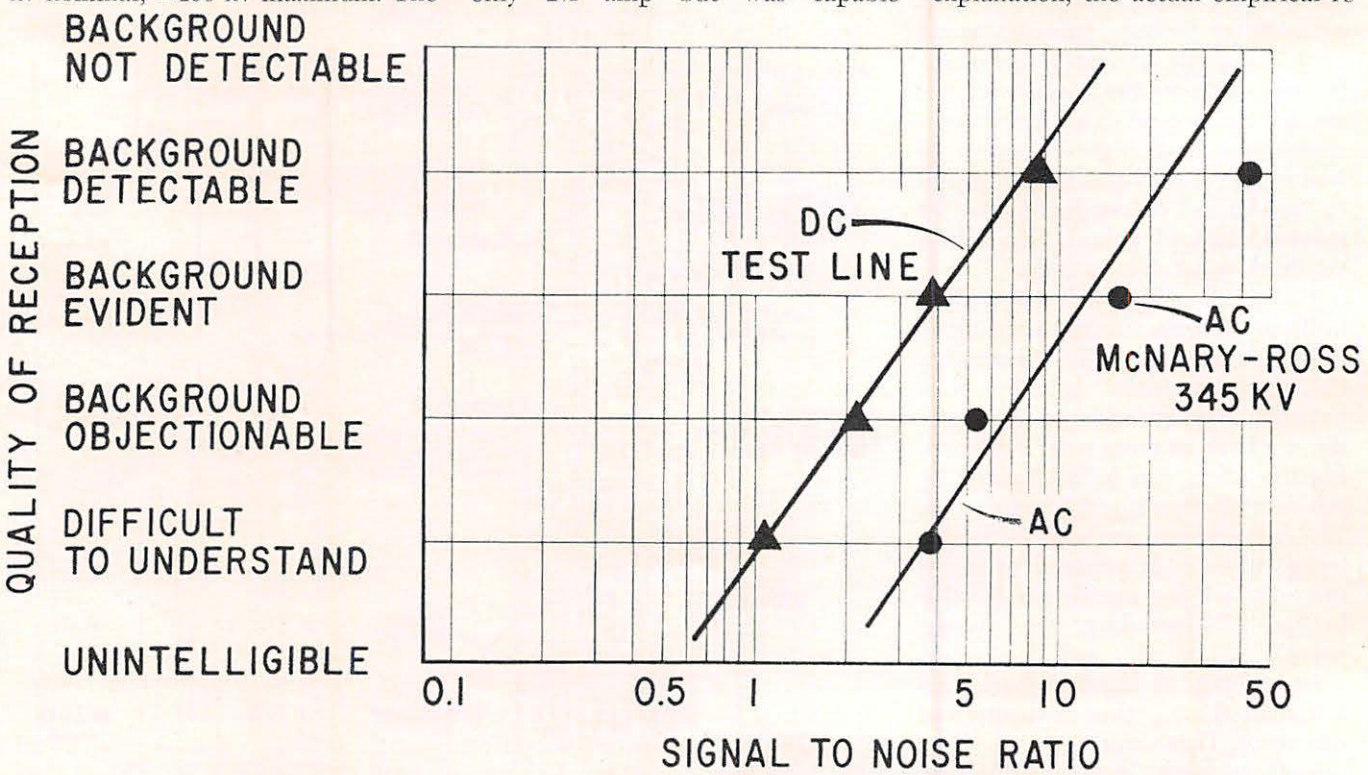


Figure 3. Test results. The unit of measurement along the ordinate, signal-to-noise ratio, is based on the measurement of the voltage gradient of the carrier signal from the broadcast station to the voltage gradient measured from the DC test line at the same frequency. Note that for the third line labeled "background evident", the radio station signal must be at least 15 times the interferring signal for AC lines whereas for the DC line, the same quality of reception is obtained even though the station signal is only four times the interference.

sults of testing with a large number of persons listening to radio broadcasts is summarized in Figure 3.

GROUND ELECTRODES

As indicated in Figure 2, each terminal will have a ground electrode connected to the mid-point of the converter bridges. At Sylmar this electrode will be located in the ocean. At Celilo and Mead, it will be necessary to construct earth electrodes in locations well removed from other underground cables or steel pipelines. At Celilo the location selected is 8 miles south of the station in wheat ranch country. For Mead the location has not been definitely determined. Normal current will be less than 50 amp flowing to the electrode. This results from a slight imbalance on the converter bridges and will be random in positive and negative directions. Under emergency conditions, however, the magnitude may reach 1800 amp for short periods.

The first DC circuit from The Dallas to Los Angeles, (Celilo- Sylmar) was originally scheduled for the summer of 1968. Due to delays in contracting for the converter equipment, the schedule was changed to the summer of 1969. Transmission lines are scheduled for completion in the fall of 1968. However, commercial operation will not be started until the winter of 1969-70. **RS&C**

HVDC in New Zealand

A letter to the Editors. The HVDC transmission overhead line from Benmore in the South Island of New Zealand runs inland northwards for 333 miles to Fighting Bay, from whence three cables run under the sea across Cook Strait, a distance of 25 miles to Oteranga Bay on the North Island side of the Strait. From here an overhead line runs inland a distance of 22 miles to Haywards where the DC/AC inverter equipment is located.

The system operates at 500 kv DC between poles with the centre point earthed, so that the conductors are ±250 kv from Earth potential. Either half of the circuit can operate alone with earth return.

Of the three cables across Cook Strait, one is positive, one is negative and the third is a spare.

At Haywards return DC current can be switched to a local substation earth or over a land line to a sea electrode 15.8 miles distant on the coast near Makara. This remote earth was provided to avoid heavy earth currents in the immediate vicinity of Haywards which is a populous area.

The statement reported at the A.A.R. Communication and Signal Section Symposium held recently in Denver presumably refers to some tests which were done at the Haywards substation. This series of tests was done to ascertain what effects would result from the passing of the main transmission D.C. earth current into the earth via the Haywards substation earthing system instead of via the earth electrode line to the sea electrode just north of Makara. This is an operating condition which can arise when certain protection equipment operates in the event of interruption to the sea electrode circuit for any reason.

During the tests, currents of 160 amps increasing by 160 amps steps up to 1120 amps were passed into the Haywards substation earthing system and the sea electrode in parallel. Because of the relatively high resistance of the overhead line out to the sea electrode it was found that about ¾ of the total current passed into the ground at Haywards and the remainder passed into the sea electrode.

No Railways Department Signaling or Communications equipment was affected by these tests. However, some Post Office equipment was affected by the difference in earth potential set up between Haywards and the various Post Office telephone exchanges in the adjoining Hutt Valley.

The earth current passed into the earthing system at Haywards resulted in a potential difference being introduced between the telephone exchange earth systems at Upper Hutt, Naenae, Stokes Valley, Lower Hutt and Wellington telephone exchanges.

Under normal conditions there are slight differences in potential between telephone exchange earths. This can be caused by a number of reasons but in the Hutt Valley area, the predominant cause is the 1500 V, DC Railroad electric traction system which parallels the telephone cable system. The design of telephone equipment is such that small earth potential differences will not affect the operation of the telephone system and, in fact, a figure of six volts earth potential difference is usually used as a design figure.

The tests made at Haywards with earth currents over 1,000 amps caused, in some cases, more than twice this figure, with the result that interference with the telephone system occurred. The type of interference varied as different types of equipment were involved, but the most common difficulty was in the inability of subscribers to release themselves from exchange equipment to make a second call. This could lead to congestion in the exchange and would prevent calls from being established if the earth potential difference was maintained for some time. No case was known of established calls being disconnected. It is emphasized that telephone calls involving junctions to another exchange were the only ones affected.

The working capacity of the HVDC system is 600 M.W. and under normal working involving the transmission of loads up to 75% of full load for long periods, no trouble is being experienced due to any interference with Railway Signaling or Communications, nor is there any trouble with the Post Office communications system, which is the national one used by all domestic and commercial subscribers.

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Cable has wideband capacity

By G. William Carter III
Manager, Application Engineering
Communications Systems
Simplex Wire & Cable Company

In recent years, the burgeoning communications needs of most railroads have outgrown the capabilities of their existing cable and open-wire facilities. Greatly expanded facilities were required to provide for many new services and functions. When it was necessary to provide these new facilities, cable systems were technically and economically unsuitable. Many railroads are using microwave radio for their more advanced communications requirement and it answers many of their communications needs today.

Congestion in the microwave bands has threatened to be a problem since the initial large scale exploitation of that medium. Consequently, many communications engineers have continued to apply modern system-design techniques to cables, cable hardware, and associated electronic equipment. This is particularly true in Europe where they have developed coaxial-cable techniques and hardware that are technically advanced and economically attractive. These techniques are now available in the United States, and they offer another solution to many system problems currently being satisfied by microwave, and are flexible enough to satisfy many future system requirements.

For a right-of-way company, such as a railroad, a coaxial-cable system offers numerous advantages, such as:

SIMPLICITY—a coaxial-cable system consists merely of the cable and a small variety of plug-in electronic modules. Engineering and maintenance on a coaxial system are greatly reduced.

PROVEN PERFORMANCE—Coaxial-cable systems have been in operation for almost thirty years in the United States, Europe, and Asia. More recently, they have been installed in locations throughout most of the rest of the world.

TRANSMISSION RELIABILITY—The performance of a coaxial-cable system is independent of atmospheric conditions. The calculated performance objectives of the system can always be met or exceeded except in the event of component failure.

LONG LIFE—Cables operated properly, within their design limits, have a record of long service. Present coaxial-cable repeaters have a calculated Mean-Time-Between-Failure in excess of two million hours. Coaxial cables do not become obsolete with the advent of new technology—they become more useful because of it.

COMPATIBILITY—Present coaxial-cable equipment is designed to couple directly at baseband frequencies to other systems using microwave or paired cable.

HIGH CAPACITY—Present coaxial-cable systems utilize bandwidths from 60 kHz to 17 mHz. Additional systems under development will provide bandwidths as high as 60 mHz.

Factors to Evaluate in a Communications System

1) Original investment—including such things as the cost of equipment, installation, engineering, acquired land and buildings, rights-of-way, route surveys, program management, etc.
2) Cost of money.
3) Investment tax credit.
4) Depreciation.
5) Annual property taxes—local and state.
6) Annual income taxes—state and federal.
7) Insurance.
8) Maintenance—including such things as routine alignment and testing; repair; upkeep of buildings, towers, poles and other structures; power equipment, upkeep of roads, fences, and other annual land costs.
9) Power costs.
10) Salvage value for retired plant—if the installation of a new communications system replaces older facilities which can be retired.
11) Reduction in maintenance as a result of retiring existing plant.
12) Other miscellaneous costs.

LOW MAINTENANCE—A coaxial-cable system requires no routine maintenance on the line equipment. Routine adjustment of the line equalizers and transmission testing of the overall system are required two to four times per year depending on the seasonal temperature extremes of the cable.

FUTURE GROWTH—All electronic equipment designed for use on coaxial cables is designed on a modular basis with mechanically interchangeable line amplifiers. To expand a system to a larger capacity, new repeaters are installed midway between the existing repeaters, and the line amplifier modules at the existing repeater locations are interchanged with new units having a wider bandwidth. At the line terminals, only a substitution of certain electronic modules is required.

FLEXIBILITY—A coaxial-cable system located along the right-of-way is accessible at all points for the addition of new services.

PRIVACY—The operation of a coaxial-cable system is independent of any government regulatory bodies and is completely under the control of the owner.

ECONOMY—Although the first cost of a coaxial-cable system may be higher than other broadband systems, the total cost over the life of the system will in many cases be significantly less. This is due primarily to lower annual operating expenses. Actual savings will vary depending on the individual system design.

LOCATION—A coaxial-cable system can be located on the owners existing right-of-way and does not require the acquisition of additional real estate, nor the maintenance of access roads.

The application of many years of development and design sophistication has resulted in coaxial-cable communication systems which are simple to install and maintain. The increased reliability of components has eliminated the need for redundancy. For example, the calculated mean-time-between-failure of the dependent repeaters is in excess of 2,000,000 hours. Actual service experience data which we have received from several telephone administrations substantiate this calculation. Since the electrical parameters of present day components are less affected by aging, and we have developed a greater understanding

Editor's Note: This is an abstract of a paper presented at the Communication & Signal Section, AAR, annual meeting in October 1967.

Features of "CAP-CEL" coaxial cable

The CAP-CEL construction is shown in Figure 1. It consists of a solid copper inner conductor insulated with an extruded tube of polyethylene. This tube is crimped in a molding machine into a series of "balloons" which accurately center the inner conductor. The outer conductor is a copper tube applied longitudinally. Two copper-plated steel shielding tapes are spirally applied over the outer conductor. This coaxial provides the following electrical characteristics which meet or exceed CCITT recommendations:

Characteristic Impedance: 75 ± 1 ohm measured at 1 mHz (Figure 2 illustrates the nominal characteristic impedance curve).

Attenuation: 8.6 ± .25 db/mile measured at 1 mHz and 50°F (Figure 3 illustrates the nominal attenuation curve.)

Dielectric Strength—capable of withstanding 1500 volts DC between conductors for not less than one minute.

Insulation Resistance—not less than 3 × 10° ohms/mile at a temperature not lower than 50°F.

Impedance regularity—The pulse echo attenuation is not less than 48 db for all coaxials and not less than 54 db for 80% of the coaxials.

The functional schematic of the line terminal is shown in Figure 4. The transmitting equipment is made up of the following circuit elements:

1) An amplifier to adjust the signal levels.

2) A pre-emphasis network which improves the signal-to-noise ratio by reducing the transmitting level of the lower frequencies in relation to the higher frequencies.

3) Pilot generators to provide line pilots for regulation and alarm functions

4) Line-building-out networks to adjust the electrical length of the last cable section to the equivalent of a standard repeater section.

The receiving equipment is made up of the following circuit elements:

1) A receiving amplifier to amplify and regulate incoming signal levels.

2) A pilot detector to act as an alarm device and send a regulating signal to the feedback network of the receiving amplifier.

3) A de-emphasis network which, in conjunction with the pre-emphasis network in the transmitter tends to minimize the variation in the whole frequency band.

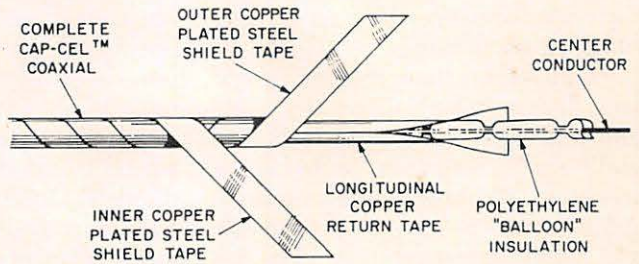

COMPLETE CAP-CEL™ COAXIAL
OUTER COPPER PLATED STEEL SHIELD TAPE
CENTER CONDUCTOR
LONGITUDINAL COPPER RETURN TAPE
POLYETHYLENE "BALLOON" INSULATION
INNER COPPER PLATED STEEL SHIELD TAPE

Fig. 1—"CAP-CEL" coaxial cable.

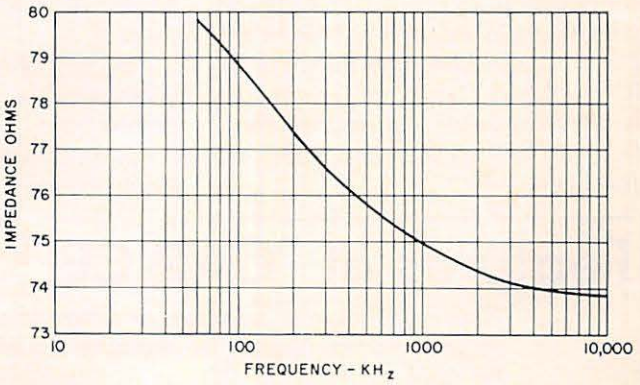


Fig. 2—"CAP-CEL" coaxial pair impedance curve.

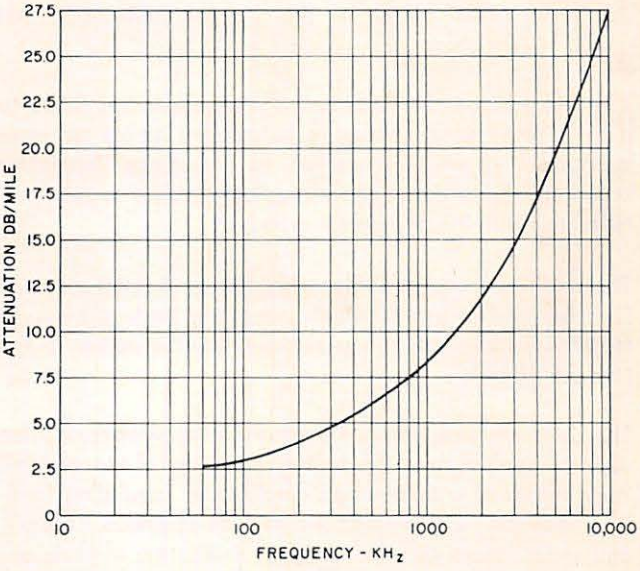


Fig. 3—"CAP-CEL" coaxial pair attenuation curve.

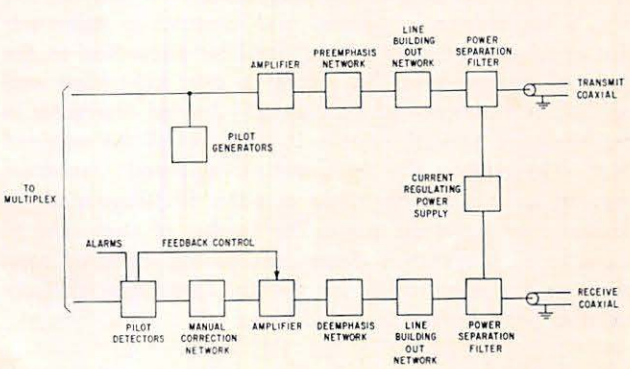


Fig. 4—Functional block diagram of line terminal.

of the aging phenomena of electronic components, modern circuits require little or no adjustment to meet their performance objectives over long periods of time.

These factors have resulted in system designs which allow the cable and repeaters to be directly buried and virtually forgotten. No testing or repeater adjustments are required. Adjustments at the line terminals and main repeaters have been reduced to occasional "touch-ups" of the manual equalizers to compensate for temperature changes in the cable which are in excess of those which can be compensated by the automatic regulators. Some systems which have rather small temperature variations do not even require these adjustments.

Routine transmission testing of the system normally is dependent on the operating philosophy of the user. Rarely is it necessary to perform routine tests more than quarterly and some users prefer to do no lineup or testing until a problem occurs.

Coaxial-cable systems are designed to interface directly into any standard multiplex equipment or with microwave radio systems and many types of cable and open wire systems. The interface impedance is a nominal 75 ohms and the interface levels are adjustable over a wide range.

The use of coaxial-cable systems is not regulated by the Federal Communications Commission, Federal Aviation Agency, or other government agencies leaving the design, operation, and control of the system completely in the hands of the owner.

The installation of the cable along the owner's right-of-way allows changes to be made in the system configuration at any time and at any place by opening the cable at the designated location to gain access to the system. These changes can involve a large number of channels or only one or two channels. In addition, composite cables are available that contain twisted pairs, quads, or singles to perform local functions. These wires may even replace an existing open wire line, thereby reducing the annual maintenance budget. Also, if the open wire line uses copper conductors, a substantial salvage might be realized.

Features of "CAP-CEL" coaxial cable: continued.

4) A manually-adjusted equalizer to compensate for seasonal variations in the characteristics of the cable.

5) A line-building-out network to adjust the electrical length of the coaxial cable to a full section.

The line terminal includes two power-separation filters to allow direct-current voltage to be applied across the inner conductors of the two coaxials to power the dependent repeaters. A constant-current-regulated power supply provides power to the dependent repeaters.

The main repeater, as shown in Figure 5, performs the functions of two line terminals operating back to back. In most system designs, this provides multiplex access to the total baseband.

The dependent repeaters shown in Figure 6 operate from current supplied over the center conductor of the coaxial. They consist of a three-stage amplifier, a regulating feedback network, a pre-emphasis and de-emphasis network, and some means of generating an indication of their operating performance. Two different types of regulating feedback networks are generally used in a system. The first is temperature-regulated and contains a thermistor that regulates the gain of the amplifier according to the ambient temperature. The second is pilot controlled and adjusts the resistance of an indirectly heated thermistor in the feedback network relative to the level of the received pilot. Generally, the temperature-regulated repeaters regulate over a ±1 db range and the pilot-regulated repeaters over a ±4 db range. The number of each type of repeater in a system is dependent on the expected temperature variation within the system. These are normally installed underground in sealed cases.

Extraction units are not currently available for all coaxial-cable systems; but where available, they provide a low-cost method of dropping multiplex channels at any location on a coaxial-cable system. Extraction units normally consist of two units; a line-amplifier unit inserted in the coaxial cable and a dropping unit which could be located some distance away. The line-amplifier unit is powered from the center conductors of the two coaxials. The dropping unit requires a separate source of a-c power and its own power supply. The line amplifier consists of two wideband hybrids and two amplifiers that compensate for the loss of the hybrids. The dropping unit includes a transmitting and receiving line amplifier to compensate for the loss in the connecting cable. The other units vary according to the multiplex configuration required at the particular extraction station.

Existing multiplex equipment, the same as that used on other broadband systems, is used with coaxial-cable systems.

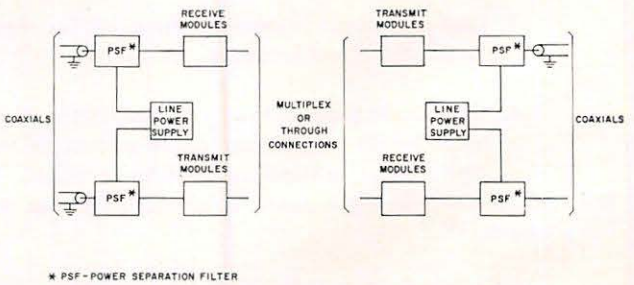


Fig. 5—Simplified block diagram of main repeater.

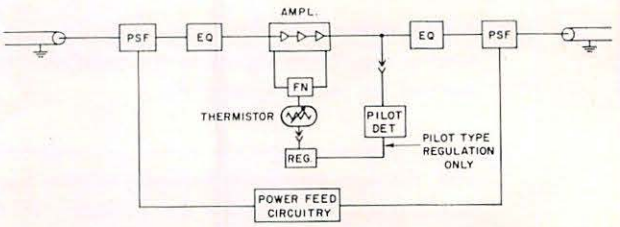


Fig. 6—Functional block diagram of dependent repeater.

Additional capacity can be obtained quite easily and inexpensively on a coaxial-cable system. The electronics equipment manufacturers have designed the plug-in modules of each of their systems to be interchangeable with similar modules in other systems of different capacity. It is, therefore, simply a matter of replacing certain modules at the line terminal, main repeater, and extraction unit sites to convert these to higher capacity. Because the different capacity systems are designed with repeater section lengths as even multiples from one capacity to the next, the existing repeater cases do not have to be relocated. However, new cases do have to be added at the midpoints of each repeater section to accommodate the additional repeaters. When rapid system growth is anticipated, these intermediate cases are sometimes installed as part of the initial installation and the cable is simply patched through the unused boxes.

The minimum performance characteristics of most coaxial cable systems are set by the recommendations of the CCITT. These characteristics include noise performance, system response, system level stability, pilot frequency stability and pilot level stability, interface impedance, and interface levels.

The CCITT recommends that the worst channel noise should not exceed three picowatts per kilometer. This would be the equivalent to a 56.8 db S/N on a 1000 mile system. In actual practice many systems better this by as much as 5 db.

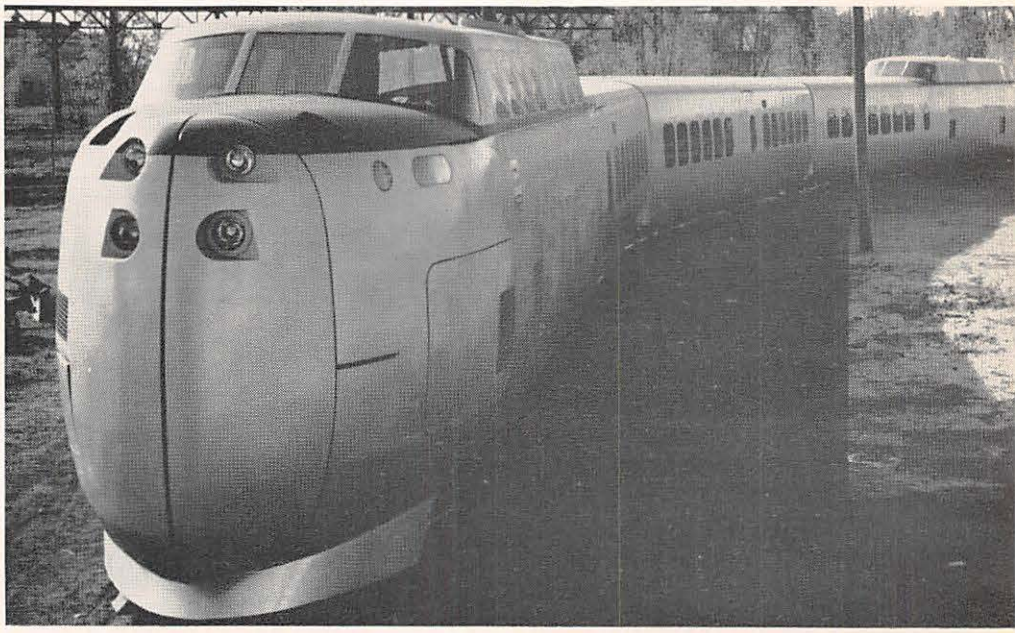
The system response of a coaxial cable system provides a flat channel across the transmitted band which is equalized to provide a deviation of less than ±1 db.

The system regulation will maintain this system response within ±1 db over the normal temperature range of the cable. The normal temperature range of these systems is 50°F ±22°F which will compensate for most buried cable. Some systems permit a temperature range as high as ±95°F which allows the use of aerial cable.

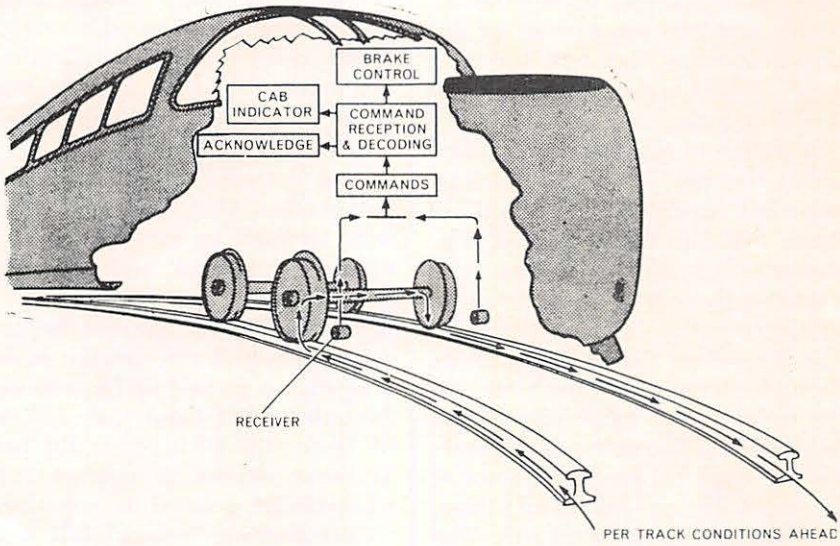
Pilot frequency stability is greater than 1 part in 10^{-5}. Many systems attain a frequency stability of greater than 1 part in 10^{-6}.

The nominal pilot level is 10 ± 0.5 dbm. Pilot level stability is ±0.3 db of the alignment level. **RS&C**

Railway Cybernetics



Turbotrain has



GRS train controls

General Railway Signal Co. train controls are used to guide new turbine-powered trains in the Boston-New York Corridor demonstrations under the High Speed Ground Transportation Act.

Two three-car Turbotrains, manufactured by United Aircraft Corporate Systems Center, Farmington, Conn., are designed for speeds up

to 160 mph, but are scheduled for about 120 mph in the demonstration runs on existing New Haven railroad tracks. The trains are bidirectional, with Power Dome cars at either end.

The train control system, supplied by GRS, includes receivers (sensing units), cab indicator, automatic braking and electronic control equipment. Electrical signals (modulated pulses) are transmitted through the rails and received by train-carried coils, or sensing units, mounted a few inches above the rails.

The cab signal indications are green, yellow over green, yellow, and lunar white—the most restrictive. Anytime the signal becomes more restrictive (such as green to yellow) because of operating and safety requirements, an audible warning sounds. This continues until the engineman acknowledges the caution signal by pressing a button. If he does not acknowledge the warning signal within a predetermined time, the train's brakes are applied automatically.

The visibility of cab signals is not affected by fog, snow, or smoke, as may occur with trackside signals. Changes in conditions ahead of the train are immediately displayed in the cab. Speed may be increased promptly when block conditions become more favorable, thus eliminating the need to proceed at an unnecessarily slow speed to the next block, as would be the case with wayside signals.

Operation of the train control system at the 180 rate code—the least restrictive mode—is illustrated in Figure 1 and in the blue print. The selector switch is manually set, prior to starting the run, to select receivers at either the A or B end of the train.

Under clear track conditions ahead, the receivers detect the 180 rate code in the track circuit and feed it to the filter unit, which passes only the track carrier frequencies of 91⅔ or 100 Hz and rejects all others, including any spurious signals. The filtered signal is amplified and fed to the decoder units. Each decoder consists of a tuned circuit which is resonant only at its specified code rate—all other rates are rejected. In this case, the 180 decoder unit responds to energize the 180 code relay. A front contact of the 180 code relay (see blueprint) feeds +28 volts

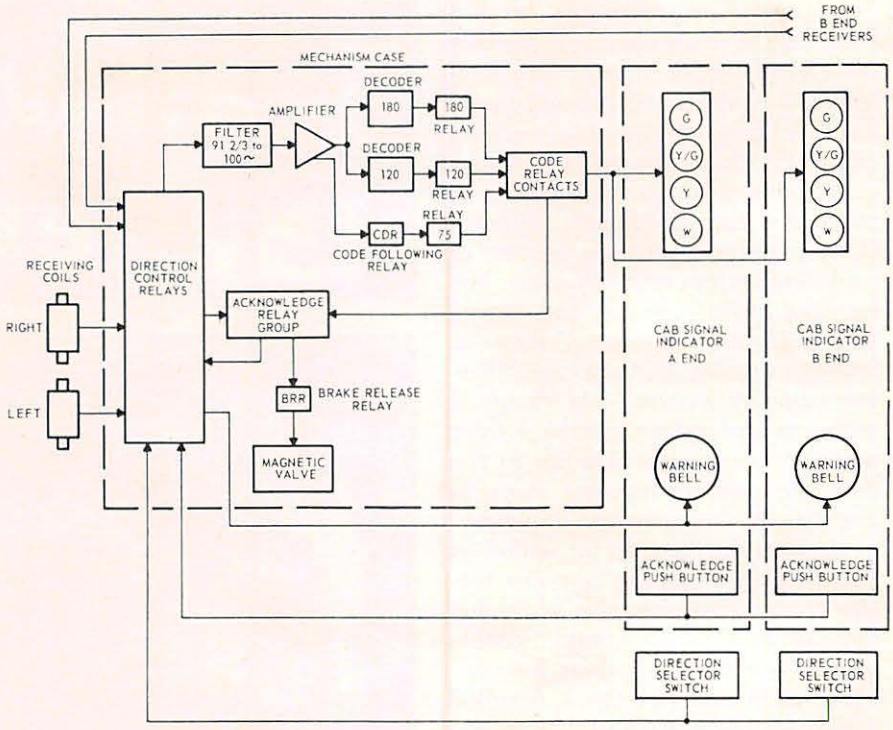


Fig. 1—Block diagram of train control system.

through back contacts on all three acknowledge relays RP (180), SP (120), and LP (75) to verify operation. Under these conditions, the cab signal displays green, the acknowledging bell remains silent, and the brakes are released. The train can proceed at full authorized speed.

The green cab signal is illuminated by +28 volts through a 180R front contact (follow the contacts shown as solid triangles), 120R back, 75R front, SP back, and the green lamp, returning to −28 volts through a 180R front contact.

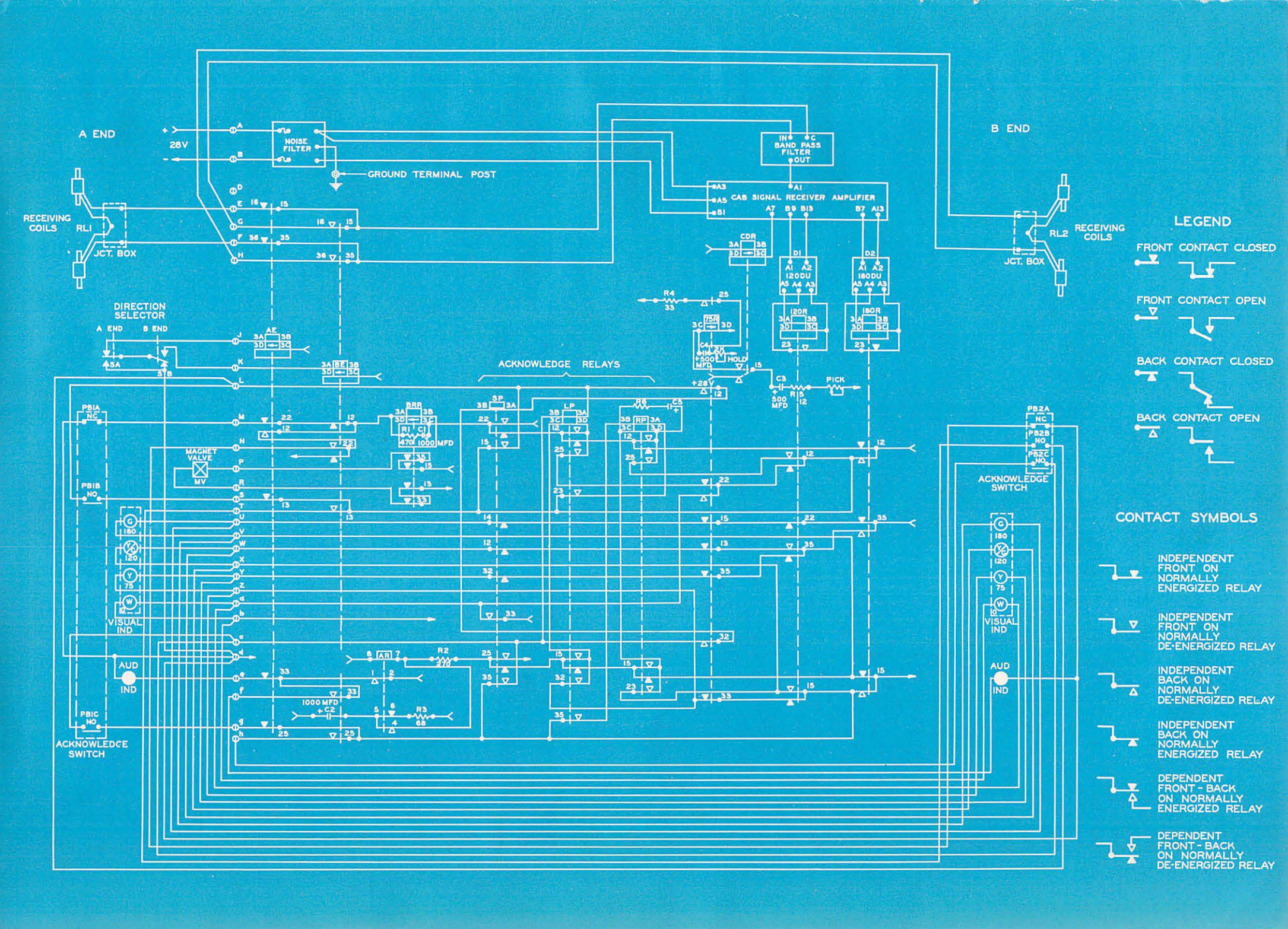
The acknowledging bell is silenced when AR is energized by +28 volts through its coil, SP, LP and RP backs in series, and 180R front to negative.

The BRR relay operates the magnet valve which releases the brakes. The relay is picked up by +28 volts through a 180 front, SP, LP and RP backs, the BRR coil, a BE back, AE front, and the NC contact on the acknowledging switch to negative.

Code-follower relay CDR operates for all codes. With CDR picked up, +28 volts is applied to capacitor C1, which charges to a value determined by the setting of adjustable resistor R1. The time constant value of capacitor C1 in this RC circuit is a function of the combined resistance of current limiter R2 and adjustable resistor R1.

During the OFF time of the code when CDR is released, capacitor C1 discharges through a CDR back to energize the 75 code relay. Simultaneously, capacitor C2 charges through the potentiometer, the setting of which determines the momentary latch time when the 75 code relay is once again deenergized by the pick-up of CDR. The time constant for this second RC circuit is determined in the same manner as that previously described. Thus, the CDR and 75 code relays are responsive to all code rates, with the 75 code relay lagging the CDR by approximately a half cycle.

(1) When the code changes from 180 to a more restrictive 120 rate and the engineman acknowledges, the following occurs: (a) The 180R relay releases, 120R picks up; and 75R remains picked up. (b) The cab signal indication changes from green to yellow over green. (c) The AR relay releases to sound the warning bell. (d) Energy is removed from the BRR relay, which releases five seconds later. (e) As the engineman acknowledges by pressing the acknowledging button within five seconds after the indication change, acknowledging relays LP and RP pick up. The LP relay releases later to pick up AR which, in turn, silences the bell. Also, BRR is again energized within the five-second release time to keep the magnet valve


A END
B END
28V
NOISE FILTER
GROUND TERMINAL POST
IN BAND PASS FILTER OUT
CAB SIGNAL RECEIVER AMPLIFIER
RECEIVING COILS
RL1
JCT. BOX
RL2
DIRECTION SELECTOR
ACKNOWLEDGE RELAYS
CDR
D1
D2
120DU
180DU
120R
180R
75R
PICK
HOLD
MAGNET VALVE
MV
VISUAL IND
AUD IND
ACKNOWLEDGE SWITCH
PB1A NC
PB1B NO
PB1C NO
PB2A NC
PB2B NO
PB2C NO
BRR
SP
LP
RP
AR
R1 C1 470Ω 1000 MFD
1000 MFD +C2
R2 270
R3 68
R4 33
C3 500 MFD
+500 MFD
LEGEND
FRONT CONTACT CLOSED
FRONT CONTACT OPEN
BACK CONTACT CLOSED
BACK CONTACT OPEN
CONTACT SYMBOLS
INDEPENDENT FRONT ON NORMALLY ENERGIZED RELAY
INDEPENDENT FRONT ON NORMALLY DE-ENERGIZED RELAY
INDEPENDENT BACK ON NORMALLY DE-ENERGIZED RELAY
INDEPENDENT BACK ON NORMALLY ENERGIZED RELAY
DEPENDENT FRONT - BACK ON NORMALLY ENERGIZED RELAY
DEPENDENT FRONT - BACK ON NORMALLY DE-ENERGIZED RELAY

energized. The brakes remain off.

(2) When the code changes from 180 to the more restrictive 120 rate and the engineman fails to acknowledge, the following occurs: (a) The 180R relay releases, 120R picks up, and 75R remains up. (b) The cab signal indication changes from green to yellow over green. (c) The AR relay releases to sound the warning bell. (d) Energy is removed from the BRR relay, which releases five seconds later. The release of BRR causes the magnet valve to call for an automatic brake application. (e) The brakes remain applied, and the audible warning bell continues to sound until the engineman acknowledges.

(3) When the code changes from the 120 to the 75 rate and the engineman acknowledges, the following occurs: (a) The 120R relay releases, and the 75R relay remains up. (b) The cab signal aspect changes from yellow over green to yellow. (c) The AR relay releases to sound the warning bell. (d) Energy is removed from the BRR relay, which releases five seconds after the cab signal indication changes. (e) As the engineman acknowledged by pressing the acknowledging button within five seconds after the indication change, the LP and RP relays pick up which, in turn, pick up the AR relay to silence the bell. Also, the BRR relay is again energized to prevent a brake application.

(4) When the code changes from the 75 rate to no code and the engineman acknowledges, the following occurs: (a) The 75R relay releases. (b) The cab signal indication changes from yellow to white. (c) The AR relay releases to sound the warning bell. (d) Energy is removed from the BRR relay, which releases five seconds after the cab signal indication changes. (e) As the engineman acknowledged within five seconds after the indication changed, all acknowledging relays pick up, the AR relay picks up to silence the bell, and the BRR relay is again energized to prevent a brake application.

(5) When the code changes from no code to any code, or from one code to a code of a higher rate, the following occurs: (a) The cab signal indication changes accordingly. (b) The AR relay momentarily releases to cause the acknowledging bell to sound momentarily, thus indicating to the engineman that a change to a less restrictive indication has taken place.

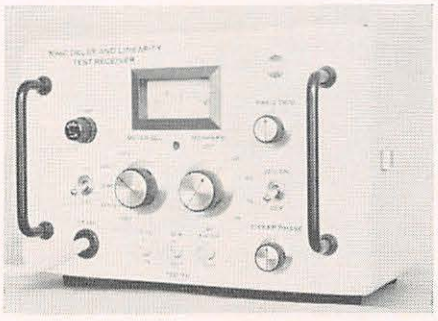
The electronic equipment is installed below the floor of the intermediate car. It is shock mounted on two mounting channels. The equipment includes: a hash filter, band-pass filter (91⅔–100 Hz), 10 relays, 2 decoders, and an amplifier. The relays, decoders, and amplifier are quick-detachable units for ease of inspection and replacement.

The inductive receivers are comprised of a laminated pole piece around which an inductive coil is wound and encapsulated. The receivers are mounted on each side of each Power Dome car, forward of the leading truck and six inches above the rails.

A directional switch is located in each cab. Prior to a run, the engineman engages the desired locomotive reverser switch, which energizes the control system for the required cab. Electrical and mechanical interlocks ensure that the cab signal system is effective for operation from one end only. This feature nullifies the effect of possible unauthorized—or accidental—manipulation of the acknowledging push button at the non-operating end.

The cab signals are comprised of four-indication visual indicators, a warning bell, and an acknowledging pushbutton, enclosed in an aluminum housing. Two vertical arrays of lights are provided, one array with color lights for the New Haven, and the other with position lights for the Pennsylvania. A hinged, flip-flop, blank-out panel is used to select the proper set of signals. **RS&C**

PRODUCT NEWS



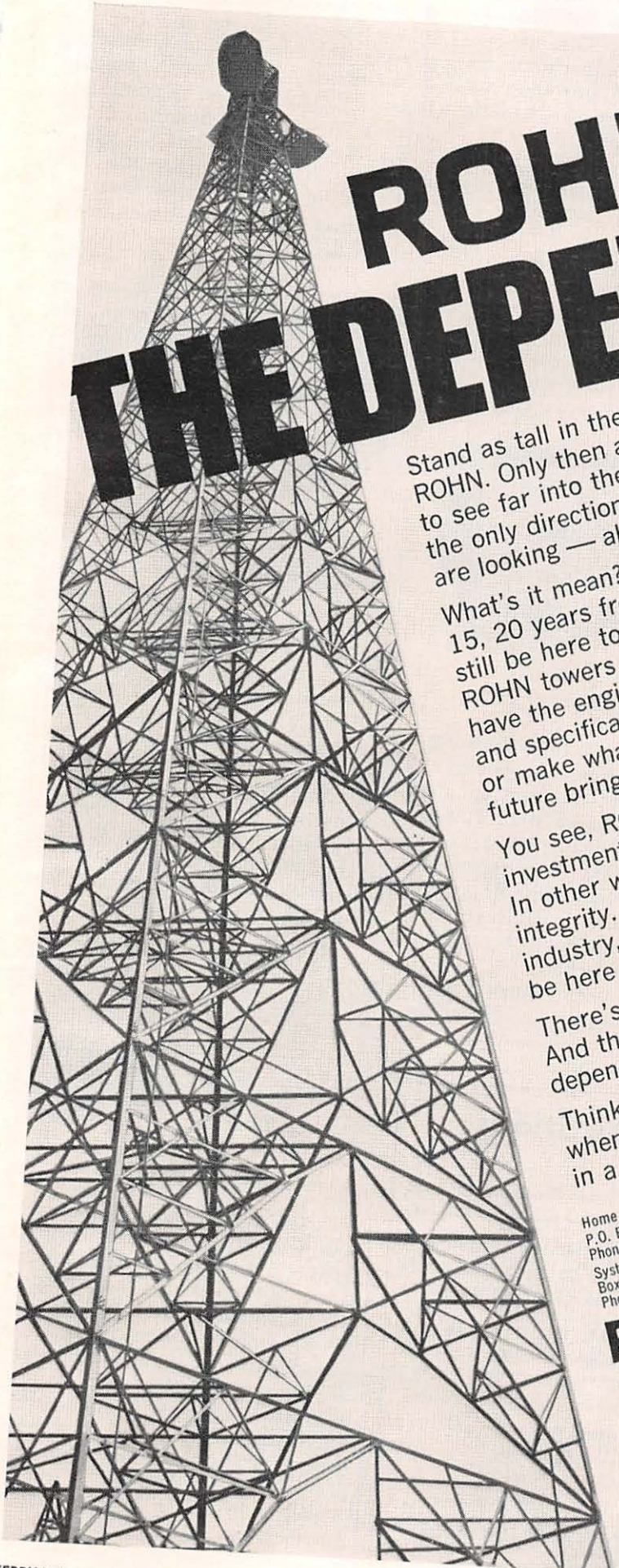
Test Receiver

A portable 70-MHz test receiver is a complete, transistorized, 115-volt AC powered unit used to convert 70-MHz IF to baseband frequencies for the measurement of communication system delay and linearity characteristics. The 70G1-MW unit is normally used with Collins companion 70E1-MW and 70E2-MW portable delay and linearity test sets. Terminal transmitters, equipped with suitable 70-MHz test points as are the current Collins microwave systems, can be linearized at the transmitter location. Heterodyne repeaters can be checked to determine the delay and linearity characteristics at their respective 70-MHz test points. *Collins Radio Co. Circle 101 on Reader Service Card.*

Grade Crossing Predictor

The new model 400 GCP for crossing protection control designed to operate with both DC coded track and AC coded cab signals, as well as other AC and DC circuits has self compensating circuitry which increases warning times under high speed-low ballast conditions. The model 400 incorporates many of the features of the present model 300, but requires less than half of the present adjustments and eliminates the need for an oscilloscope for set-up and maintenance. *Marquardt Industrial Products. Circle 102 on Reader Service Card.*

• GENERATORS: Thermo-electric gas-fueled generators, designed to produce reliable low-cost power in remote areas in all types of weather are featured in a newly illustrated 16-page brochure. Information is also provided to show how the generators can be used to most economic advantage; operating theory, including matching to resistive load and matching to a battery; installation, operation and servicing; application data with details on charging various storage batteries. *General Instrument Corp. Circle 103 on Reader Service Card.* *(Please turn to page 30)*



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Circle 13 on reader service card

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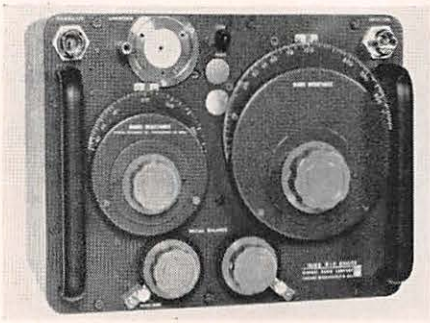


Radio-Frequency Bridge

A new impedance bridge has been developed for accurate measurements in the 400 kHz to 60 MHz range. The screw-type terminals on the basic instrument can be adapted to coaxial systems with appropriate adaptors. The resistance range of the bridge is 0 to 1000 Ω, and the reactance range is ±5000 Ω at 1 MHz. *General Radio Co. Circle 104 on Reader Service Card.*

Overlay Track Circuits

The new modulated electronic track circuit (METC) is a pulse-code controlled audio frequency overlay device for use in approach circuits for grade crossing protection and other applications where high external interference eliminates the use of ordinary tone systems. The METC can safely be used in areas having AC signal circuits and coded cab signals. A wide selection of operating frequencies is available for specific applications. Two modulation rates and two pulse-coding systems can be selected, providing railroad signal circuit designers with the ultimate in flexibility and safety.

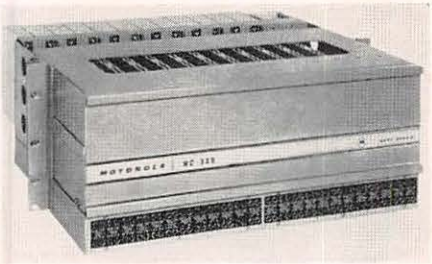
The new pulse modulated control (PMC) equipment extends the application of METC by adding the capacity to transmit data for controlling the aspects of wayside signals. This new unit is available in a rack-mounted design as well as separate modular units similar to the existing electronic track circuit—model 100. *Marquardt Industrial Products. Circle 105 on Reader Service Card.*

FS Voltmeter

Model 3140 is a fully transistorized battery operated frequency selective voltmeter designed to give performance up to 8.5 MHz. This instrument is supplied with five pre-set crystal controlled frequencies to match pilot frequencies of present day high-density microwave systems. Several options are available for frequency selection.

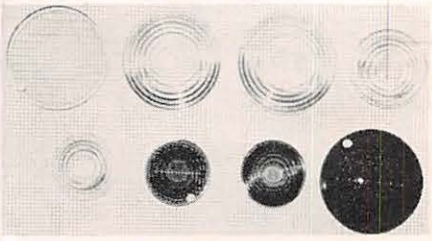
Model 3140 pilot voltmeter is designed to operate from a 75-ohm line with attenuation to control sensitivity of measurements from –90 dbm to –9 dbm into 75 ohm (8.6 mv to .1 volt) and measurement accuracy of ±1 db at ±250 Hz of indicated frequency. Spurious and intermodulation is greater than –40 dbm.

The Model 3140 uses ten "D" cells for power. Size and weight: 10½" x 6¾" x 5¾" at 12 lb. *Rycom Instruments Inc. Circle 106 on Reader Service Card.*



Multiplex System

The MC-300 multiplex system meets CCITT frequency allocations, VF response and signaling requirements. Modular construction is used with glass epoxy 4W modem card and termination card. All modem cards are identical with no frequency determining elements. Voice frequency terminations include solid-state E & M leads, and all others are derived with applique overlay cards. Input power is 24 or 48 volts DC or 120 volts AC. *Motorola Communications & Electronics Inc. Circle 107 on Reader Service Card.*



Plastic Lenses

Various types of plastic lenses are now available including optical types of 5⅜" diameter and 3½" focus in red, green, yellow, blue, purple, lunar white and clear. Also available are spreadlight lenses of 30 deg spreadlight and 10 deg deflection: 30 deg spreadlight with 15 deg downward deflection in various colors. Outer and inner doublet type lenses are also available. Diameters of lenses are 8⅜" and 6⅜ ". *General Signals Inc. Circle 108 on Reader Service Card.*

Railway Signaling & Communications

14 E. Jackson Blvd., Chicago, Ill. 60604
Attn: R. W. McKnight

Reader Service Card 2/68

Circle numbers for more information about products and services. **1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51**

101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130

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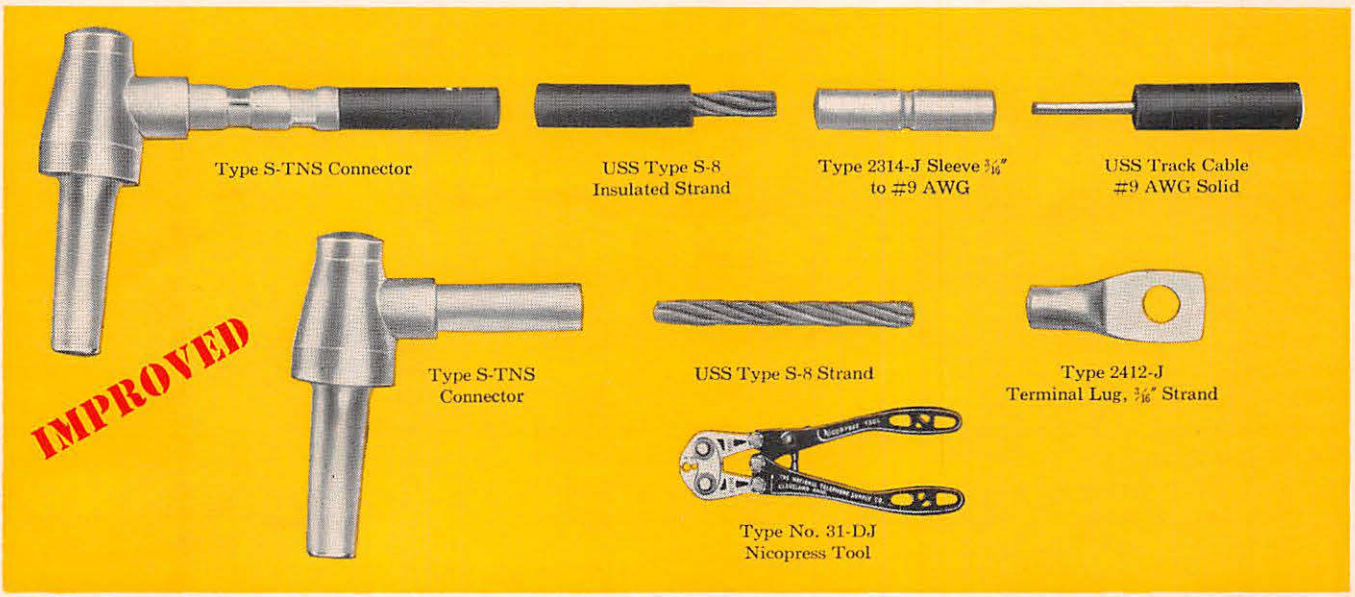
THIS COUPON MUST BE USED ON OR BEFORE APRIL 30, 1968

Improved track circuit connections with "Do-it-yourself" USS Tiger Brand S-8 Strand and Track Cable

With USS S-8 Strand and USS Track Cable plus the improved fittings illustrated, track connections are now easier to make in the field. Using the "J" groove of the popular 31-DJ Nicopress tool (illustrated), the cable or strand is quickly and positively locked into the fittings—with only two presses.

USS S-8 Strand is available bare in 250-foot coils and 2500-foot reels, and insulated in 100-foot coils and 1000-foot reels. USS Track Cable #9AWG Solid is available in 2000-foot reels. The fittings illustrated below, plus splicing and reducing sleeves for different wire sizes, are all available from United States Steel. If you prefer manufactured signal bonds and connectors, U. S. Steel maintains a complete stock of USS TIGERWELD Rail Bonds.

For more information, contact the United States Steel sales office nearest you, or United States Steel, P. O. Box 86, Pittsburgh, Pennsylvania 15230. Export Distributor: United States Steel International (New York), Inc., P. O. Box 75, New York 10008.


Type S-TNS Connector
USS Type S-8 Insulated Strand
Type 2314-J Sleeve 3/16" to #9 AWG
USS Track Cable #9 AWG Solid
IMPROVED
Type S-TNS Connector
USS Type S-8 Strand
Type 2412-J Terminal Lug, 3/16" Strand
Type No. 31-DJ Nicopress Tool

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USS United States Steel

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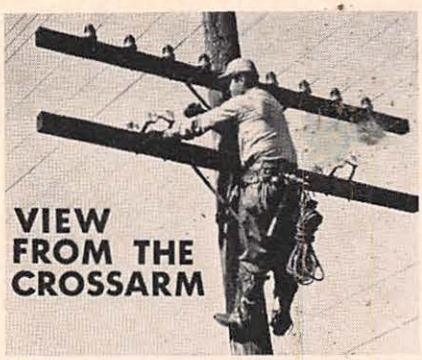


For the beginner in signaling and/or communications, three programmed courses or self-teaching books are available that can help him master the mystery (and it really isn't) of electricity, electronics and transistors. Prepared by the New York Institute of Technology, these three McGraw-Hill books constitute an excellent course in the fundamentals so essential for signal and communications men.

No better comment can be made than that contained in the preface. For example: "The Programmed Course in Basic Electricity offers a tested procedure for taking the first step toward electronic specialization. Starting with the assumption that the student has only a meager back ground in electricity, this course develops the basic electrical concepts essential to later studies in electronics. The carefully organized logical sequence of interrelated steps permits the student to proceed at a pace best suited to his abilities and needs. He is constantly aware of his progress by means of immediate feedback as well as many checks and repetitions. He is his own tutor and his own examiner. Visual instruction is aided by clear, uncomplicated diagrams. Mathematics has been kept at a minimum, especially in the earlier sections of the work, to enable the nonmathematically-minded reader to achieve a firm grasp of the necessary concepts.

"There is one major prerequisite for the successful completion of this course: *interest*. An inner drive to learn is often a more important ingredient than a high IQ. Armed with determination and perseverance, the man with a strong desire to learn simply cannot fail."

Subjects covered in this basic electricity course include: static electricity, charges in motion, circuit fundamentals, power and series circuits, parallel circuits, series-parallel circuits, voltage dividers, magnetism, further principles of electromagnetic induction, introduction to generators, electrical meters, fundamental concepts of AC, inductance, capacitance, transformers, power in AC circuits, AC resistive circuits, RL circuits, RC circuits, RCL circuits and resonance.

A Programmed Course in Basic Electricity, McGraw-Hill Books, Price: $6.95.

The Programmed Course in Basic Electronics starts with the assumption that the student has a background in electricity and develops basic electronic concepts essential to later studies. Subjects covered include: electron emmission and diodes, circuit notations, triodes, basic triode action, tetrodes, pentodes, power-amplifier tubes, amplifier classes, audio coupling and amplification controls, audio amplifiers, radio-frequency amplifiers, cathode followers, oscillation principles, LC oscillator circuits, crystal oscillators, modulation fundamentals, detection, detectors and AVC, superheterodyne principles, superheterodyne stage analysis, basic power supplies and analysis of a typical superheterodyne receiver.

A Programmed Course in Basic Electronics, McGraw-Hill Books, Price: $6.95.

A Programmed Course in Basic Transistors starts with the assumption that the student has a background in the fundamentals of electricity and electronics, and develops the basic electrical concepts related to transistors. Subjects covered include: semiconductor fundamentals, transistor fundamentals, parameters, equivalent circuits and characteristic curves, parameter calculations, bias stabilization, using characteristic curves and charts, audio amplifiers, tuned amplifiers, wideband amplifiers, oscillators (LC type), transistor construction methods, reading transistor specifications and transistor measurements.

A Programmed Course in Basic Transistors, McGraw-Hill Books, Price: $7.95.

The price for the three-book set is $21.85. **RS&C**

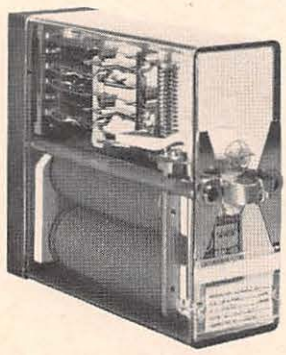
NEWS BRIEFS

• BELL TELEPHONE LABORATORIES model II PICTUREPHONE see-while-you-talk set will be tested this fall on Pittsburgh-New York video telephone service. Selected offices in Westinghouse Electric Corp. headquarters in Pittsburgh and at its New York City locations will be linked. The trial with Westinghouse is scheduled to start in September 1968 and last for 3 to 4 months. Forty PICTUREPHONE sets—28 in Pittsburgh and 12 in New York—will be used for both inter- and intra-city communications. American Telephone & Telegraph Co. said it hopes to be able to introduce PICTUREPHONE service to a limited number of customers in the early 1970s.

The model II set contains a new television camera tube that provides a better picture under both poor and normal lighting conditions and makes it possible to alter the field of vision for close-up or wide-angle viewing. The screen of the set is 5.5" wide by 5" high. This larger screen together with a new camera lens centered over the screen, gives the user more freedom to move from side to side. PICTUREPHONE units are small enough to be placed on an office desk. An associated TOUCH-TONE telephone is used for making calls. Parties talk and hear over a speaker-phone but can switch to the telephone handset if they wish.

• FEDERAL COMMUNICATIONS COMMISSION has permitted Western Union's Infocom service covering transmission of communications within a customer's network through computer centers on a store-and-forward basis, and its Sicom (securities industry communications service) tariffs to be effective Jan. 1, 1968. WU said Infocom is available between points in the continental U.S. and "provides facilities and equipment for the communication purposes of the customers and authorized users in the transmission of communications between infocom stations which comprise a customer's network, on a store and forward bas-

(Please turn to page 34)



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MEMBER RPI RAILWAY PROGRESS INSTITUTE

3444

Circle 12 on reader service card

(Continued from page 32)

is, through computer centers located on the telegraph company's premises," published *Telecommunications Reports*. The computer centers are located in Atlanta, Chicago, New York and San Francisco.

"The facilities furnished permit the transmission of communications between customer stations or authorized user stations and the telegraph company's computer centers. Infocom service is available 24 hours per day, seven days per week. The service is offered by the telegraph company for a minimum period of three months and may be cancelled thereafter on not less than one month's notice.

"The basic charges for infocom service comprehend (a) an access charge per station which includes basic station equipment and an access line connection to the communication center and (b) a usage charge which is related to the aggregate number of minutes of use during a monthly billing period.

"The service shall be used only for communications in which the customer has a direct interest, transmitted (a) from one infocom station to another inforcom station in the same customer network, or (b) between an infocom station and the telegraph company's computer center. An infocom station in one customer network may not send communications to an infocom station in another customer network."

• LOUISVILLE & NASHVILLE has ordered 50 sets of 72/12-volt radio units from the Signal & Communications division of WABCO for installation in new cabooses.

L&N will install a microwave system between Louisville and Nashville, 187 miles. Terminal stations will be at the L&N building in Louville and at its communications center in Nashville. Seven repeater stations will be spaced about 25 miles apart. Installation will begin shortly, and the system will be completed by the end of this year.

Also, L&N will install six hotbox detectors this year, and modify one.

• NORTHERN PACIFIC has received approval of the Federal Railroad Administration to install a traffic control system replacing an existing automatic block signal system arranged for current of traffic operation on two tracks between Vancouver and Vader, Wash., 60 miles. NP also received relief from Section 236.21 (formerly 136.21) of Ex Parte 171 to the extent that it can install 44 signals to the left instead of over or to the right of the track governed.

• PENNSYLVANIA has installed transducers made by Servo Corp. of America to provide advance warning at highway grade crossings in the Washington-New York territory where high-speed Northeast Corridor trains will be running this spring. The advance warning track sections were recently lengthened, and a new arrangement for selective speed timing was devised to avoid excessive advance warning time for trains operating at slow speeds.

This circuit arrangement includes a Servopole transducer attached to the rail a short distance in advance of the high-speed advance warning section. When the leading wheels of the

(Please turn to page 36)

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Westinghouse Electric Corporation, Transportation Center, is a newly formed activity organized solely to help develop revolutionary new mass-transit systems. The transportation future of the world's largest cities lies with Mass Transit. Get in on the ground floor with Westinghouse!

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Background with solid state digital computer logic essential with possible experience in railroad or subway systems. Assignments will include the development of systems logic for rapid transit trains as well as control and prepare hardware specification for required functional units. E. E. Degree required.

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To cover all concepts of automatic train control systems, communications systems, system engineering studies and hardware components as well as control and supervisory computer systems. E. E. Degree required or electronics and experience in railway signaling and/or communications or computer applications in research engineering or sales.

COMMUNICATIONS ENGINEER

Experience in office wiring equipment layout as done with a railroad doing layout of dispatchers' and wire chiefs' offices. Work involves assigning cable conductors, terminals, sizing cables and duct lines. B.S.E.E. Degree required.

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Westinghouse

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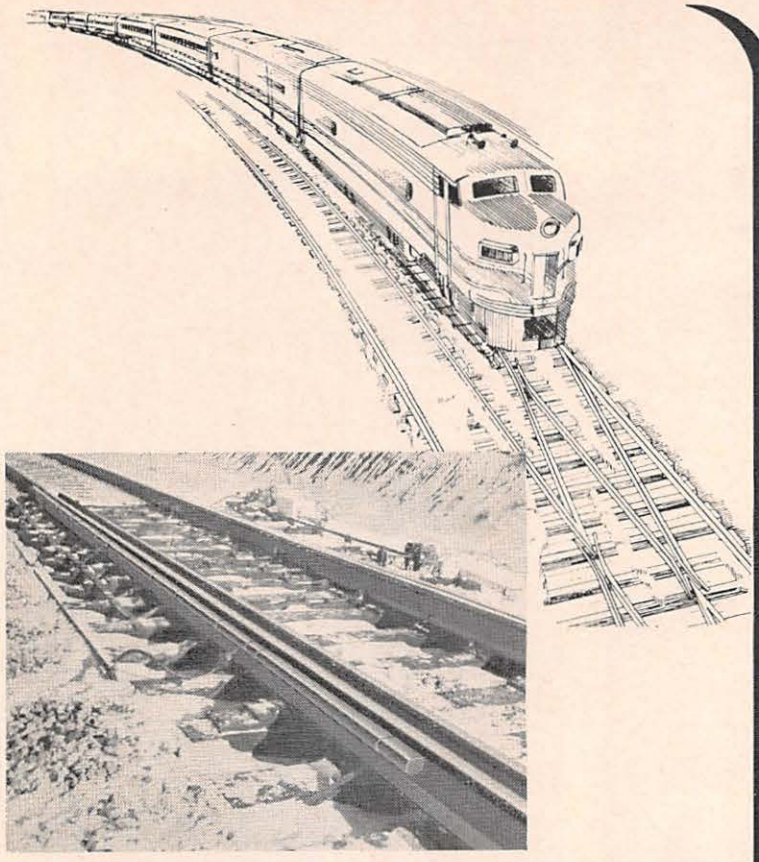

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Circle 17 on reader service card

NEWS BRIEFS

(Continued from page 34)

train pass over the transducer, a constant potential DC power source is applied to a retarded pick-up relay circuit. This circuit arrangement checks the time for the train to travel from the transducer to the start of the high-speed advance warning section. Appropriate warning time is determined for the train involved through the selective speed timing control.

• PRIVATE MICROWAVE systems of five major West Coast power organizations can now be interconnected, according to an authorization from the FCC. Involved in the Pacific Intertie for the transmission of bulk power via DC high-voltage transmission lines, the five private microwave systems are owned by Pacific Gas & Electric Co., Southern California Edison Co., San Diego Gas & Electric Co., Department of Water & Power of Los Angeles, and the Bonneville Power Administration.

FCC said that their permission was not required because the organizations were proposing "interconnection of the separate microwave systems operated by the participants to permit communication for cooperation and coordination of their own activities in connection with the operation and maintenance of the electric generation and distribution facilities of each licensee involved in the Pacific Intertie."

• SANTA FE has ordered three fully automatic hotbox detector systems from Servo Corp. of America. A typical AT&SF system includes the basic system, alarm monitors, failure indicator and remote locators. Santa Fe now has 58 Servo hotbox detectors.

• UNION PACIFIC is modernizing and consolidating traffic control systems. New and more sophisticated equipment is now in place and operating at Salt Lake City, Utah, and Albina, Ore., and a third installation is undergoing tests at Kansas City, Kans.

The new equipment at Salt Lake replaces UP's older CTC system at Las Vegas, Nev., and a major portion of the older system at Salt Lake. Pri-

or to completion of the new Salt Lake Center, UP had two older type machines at Las Vegas to control the territories of Caliente, Nev., to Las Vegas and Las Vegas to Daggett, Calif. Two more machines at Salt Lake controlled the CTC territory from Salt Lake to Lynndyl, Utah, and from Lynndyl to Caliente. With the new equipment, dispatchers in the Salt Lake traffic control center now control the entire territory from Salt Lake to Daggett.

The new Albina installation replaces the road's old CTC center at LaGrande, Ore., and enables dispatchers to control the entire traffic control territory from Huntington to Biggs, Ore., from the new location.

Testing of the new traffic control equipment at Kansas City is scheduled to be completed and the new machines placed in service sometime around the first of February. When in service, the new Kansas City traffic control center will take over duties of the old CTC center at Marysville, Kans., and will control traffic over the line from Menoken, Kans., to Gibbon, Neb. Long range

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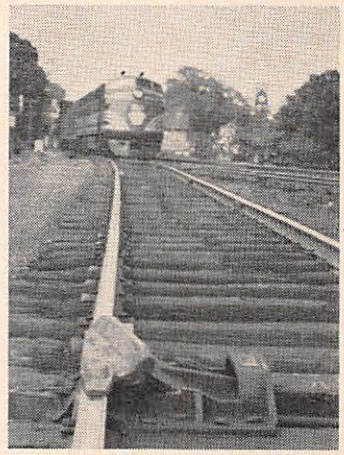
The main track needs positive protection. No available means of guaranteeing its security should be omitted.

Signals and track circuits have their field, but neither provides the physical protection afforded by a Hayes Derail.

Hayes Derail—the most universally used track device. Designed and built by men whose only business is railroads.



Free leatherette ring-binder catalog of world's most-specified derails, bumping posts and wheel stops (including periodic supplement sheets). Write on letterhead.

Specialists since 1903 in side track security

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RICHMOND, INDIANA 47374

Circle 18 on reader service card

(Continued from page 37)

planning also calls for the Kansas City center to take over traffic control duties on a short segment of CTC territory from Topeka, Kans. to Silver Lake, Kans., now handled from Topeka.

D. F. Wengert, vice-president, operations, said the new machines represent a big improvement allowing an operator to control his territory with much less effort. The old machines were as large as 15 feet from end to end and required the operator to move from one position to another to control traffic at different stations on the territory.

A central control console on the new machines enables the operator to control all stations in his territory from one location. In addition, it is modular in construction permitting the territory controlled by the machine to be expanded simply by stacking more track plan modules onto the machine.

Railway Personnel

• ILLINOIS CENTRAL: **T. J. Kremer,** supervisor signals, Champaign, Ill., appointed assistant to signal engineer, Chicago, succeeding **E. B. Platt,** retired. **J. H. Stroud,** project manager, information and control systems, Chicago, appointed supervisor signals, Carbondale, Ill., succeeding **L. R. Griffith,** retired. **William Lyons, Jr.,** appointed supervisor of signals, Champaign, Ill. **John H. Bland** appointed supervisor communications equipment, Jackson, Miss. **J. M. Coverick** appointed project manager communications at Chicago. **C. H. Owens,** supervisor signals, Waterloo, Iowa, appointed supervisor communications and signals at that point. **W. R. Brown** appointed supervisor signals at New Orleans, La. **L. W. Stearns,** supervisor communications and signals at Freeport, Ill. appointed manager of engineering, Chicago. **D. G. Murphy,** supervisor communications, Waterloo appointed supervisor communications and signals there. **J. C. Taylor** appointed engineer of communications Chicago.

Mr. Platt began working for the IC signal department at Fulton, Ky. in 1923, after having worked in the signal departments of the AT&SF and the GM&O. He advanced on the IC through the positions of signalman and signal maintainer in Chicago. He then moved into the signal engineer's office as a draftsman, later becoming an estimator and signal inspector. From 1942 to 1946, Mr. Platt was supervisor of signals on the Kentucky division. He was appointed field signal engineer in Chicago in 1946, and a year later promoted to office engineer. In 1956, he was promoted to assistant to signal engineer.

E. B. Platt
Illinois Central

Frank H. Underwood
Moore Associates

• PENNSYLVANIA: **James A. Early,** engineer communications and signals at Chicago transferred to Pittsburgh, succeeding **A. B. Swartzwelder,** appointed superintendent signals and communications, Detroit, Toledo & Ironton at Dearborn, Mich. **Frank J. Fotta,** assistant division engineer at Buffalo, N.Y., appointed engineer communications and signals at Chicago, succeeding Mr. Early.

• SEABOARD COAST LINE: **J. H. Barber,** supervisor communications and signals at Jacksonville, Fla. has retired.

Supply Trade News

• ABEX CORP.: **Earl E. Frank,** project engineer, has been appointed assistant chief engineer for trackwork products. He joined the company in 1940 as a draftsman, and later served as a district engineer in Seattle and Buffalo. In 1961, he was appointed project engineer in Chicago. He will be headquartered at Mahwah, N.J.

• MOORE ASSOCIATES: **Frank H. Underwood** has been appointed manager of the newly established field office at 11615 Francis Place in the Westwood area of Los Angeles, Calif. A graduate of UCLA, Mr. Underwood comes to Moore from IBM, where he was a marketing representative in the Data Processing division.

Obituaries

• J. M. AUSTIN, assistant signal construction supervisor, Seaboard Coast Line at Kingsland, Ga., died recently.

• WARWICK R. BAKER, 64, assistant to chief engineer communications and signals, Seaboard Coast Line, died last month. (For biographical information and photograph, see RS&C Nov. 1967, pages 55-57.)

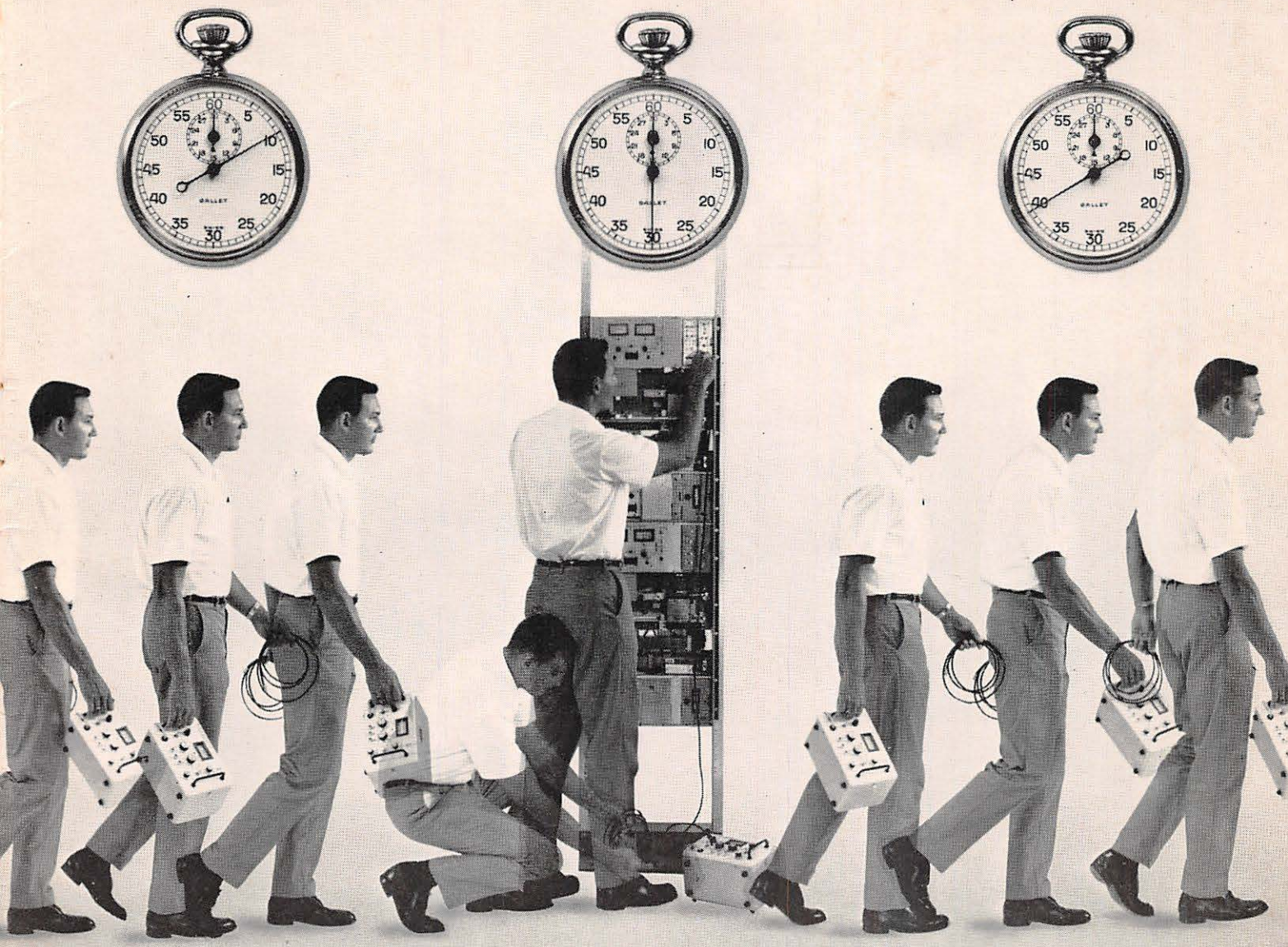
• SEDGWICK N. WIGHT, retired engineer with General Railway Signal Co. died Jan. 5 in Rochester, N.Y. He was 88. He was the inventor of absolute permissive block signaling, centralized traffic control, and NX (eNtrance-eXit) push button interlocking control.

Mr. Wight was born in Andover, Ohio on March 21, 1879. He received his B.S. degree from Hiram College, Ohio, in 1903. In the following year he started as a draftsman for the Lake Shore & Michigan Southern in their signal department at Cleveland, Ohio, and later became signal inspector. In 1910 Mr. Wight joined the General Railway Signal as assistant commercial engineer. At the time of his retirement, he was engineer of train operation. In addition to his inventing APB and cTc, patents issued to him totaled over 90, ranging from basic railway signal devices and systems to airway traffic control systems.

Mr. Wight received the "Modern Pioneer" award in 1940 from the National Association of Manufacturers and, in 1947, the Henderson Medal from Franklin Institute. Both these awards were in recognition of his achievements in contributing to the safety, speed, and reliability of railroad operation.

HVDC Papers

Copies of the Papers and the Proceedings of the AAR Symposium on High Voltage Direct Current transmission are available for $5 per set from George McCann, Secretary, Communication & Signal Section, AAR, 59 East Van Buren St., Chicago, Ill. 60605.



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That's how long it takes one man to make these adjustments on Collins new "D" series of remodulating microwave systems. These adjustments — the two most important of the maintenance procedures — can be made while the system's in service.

With new transmitter afc circuitry (a built-in receiver), rf deviation can be checked and adjusted with only one piece of equipment — Collins' new inexpensive pilot selective voltmeter. Level adjustments can be made easily and accurately at all baseband points with a Collins 70D1-2MW Deviation Calibrator and an ac voltmeter.

That's all the test equipment needed for minor maintenance. It's lightweight, inexpensive, and specially designed for field operations. All other test equipment — including metering equipment, jackfields, isolated coaxial test jacks, test points, and waveguides — is built in. All with front access.

For additional information on the most easily maintained remodulating microwave system in the industry, contact Collins Radio Company, Microwave Marketing Department, Dallas, Texas. Phone: (214) AD 5-9511.

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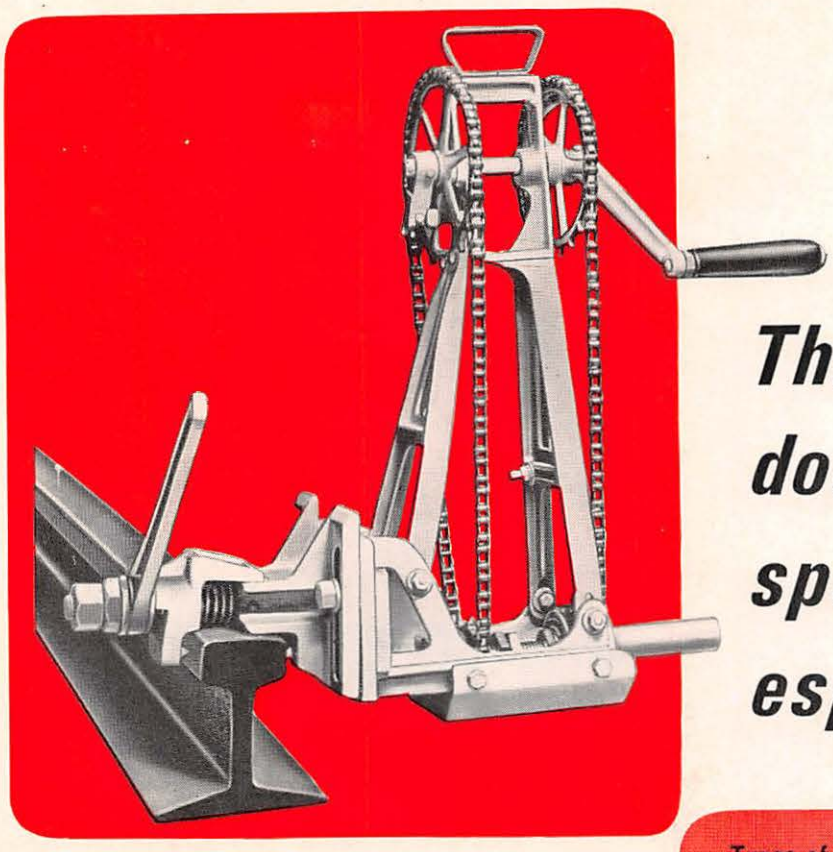

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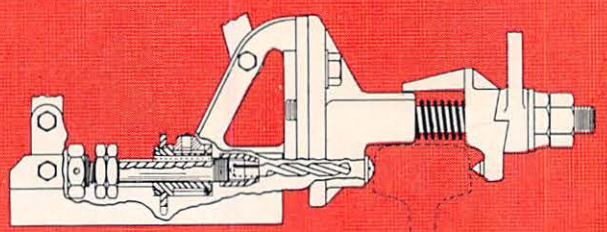
BELOW: Hyduty type (not clamp) chuck and spindle for Western B-W Bonding Drill is available in 9/32" and 1/8" flatted shank drill sizes. Specify diameter of drill bit when ordering.

NOTE: A spindle having a collet chuck is also available to handle a standard 3/8" x 3" round shank twist drill bit.



Outline drawing of the clamp mechanism shows the hardened tool steel points inserted in the clamp jaw. These points grip the side of the rail head. No base plate is necessary. This type clamp clears all standard angle bars.

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WESTERN RAILROAD SUPPLY COMPANY

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